Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

APRIL 1981/9

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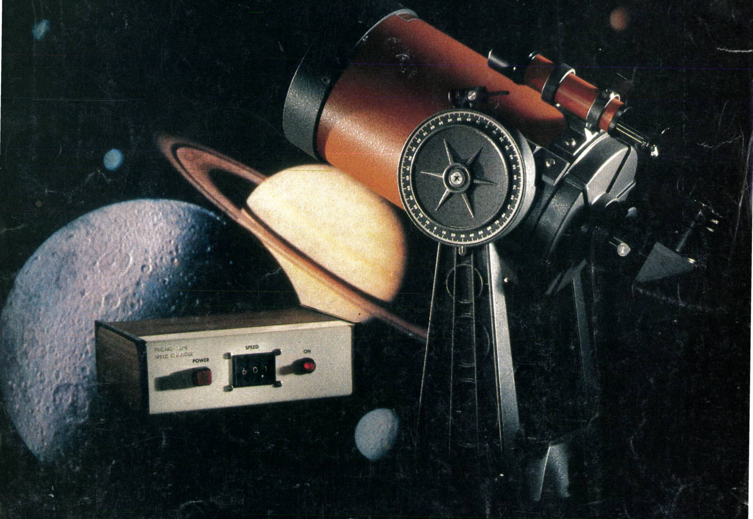
An Oscilloscope Buyer's Guide

Expanding Microcomputer Memories

Build a Rumble-Cancelling Circuit

Speed Control for Synchronous Motors



Tested in this Issue:

APF Imagination Machine

Tektronix T922 Dual-Trace Scope

In hi-fi, up until now, sound was the whole picture.

Since the very beginning, hi-fi has appealed to one sense: your hearing. The rest was up to your imagination.

Now Pioneer brings you closer to the reality of performance than you've ever experienced at home: LaserDisc.™

Now you can hear and *see* a concert or a movie as easily as you can play a record. With sound that's pure hi-fi.

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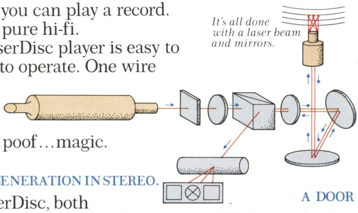

It's all done with a laser beam and mirrors.

THE SOUND: A NEW GENERATION IN STEREO.

With Pioneer LaserDisc, both channels are completely discrete from each other. It's stereo in its truest sense. And since the disc is read by a light beam rather than a video head or needle, with normal use, it doesn't wear out from play. In addition, unlike conventional records, you can handle the LaserDisc as much as you wish. Even minor surface scratches won't effect the superb audio and video fidelity. You can enjoy the disc forever.

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Sports like NFL Football.

THE PICTURE: BETTER THAN HOME VIDEO TAPE.

The Pioneer LaserDisc player offers a picture with actually 40% better resolution than the picture delivered by a home video tape player. A picture of the highest broadcast quality. For the first time on your television set, video fidelity is matched by audio fidelity.

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Pioneer Artists and MCA/Discovision discs like Paul Simon, Liza Minelli, Loretta Lynn, Jaws, Animal House, The Blues Brothers, the NFL.

A DOOR TO EDUCATION.

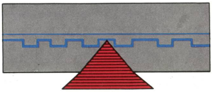
With standard-play discs, you can create your own instant sports replays at home, you can go in fast motion, slow motion, one frame at a time, even stop motion indefinitely. But LaserDisc offers something far more revolutionary. Everyone of the up to 108,000 frames on the disc is coded. And a built in micro-computer lets you access any individual frame at will. This means you can go to your favorite scene in a movie or song in a concert in seconds.

But that's merely the beginning. On one disc you can stroll through the National Gallery and study art masterpieces one masterpiece at a time.

And since play can't wear out the disc, they can be studied forever.

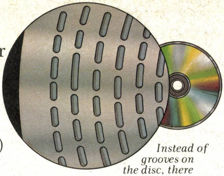
THE FUTURE IS IN REACH.

One of the most surprising parts of this new technology is that it's affordable.



A beam of light instead of a needle.

The Pioneer LaserDisc player has a suggested retail price of $749.* (Optional remote control just $50* more.) As surprising, a full length movie on LaserDisc can even cost less than taking your family out to the movies. And about half or a third of the price of that same movie on video tape.



Instead of grooves on the disc, there are microscopic pits.

YOU WON'T BELIEVE IT UNTIL YOU SEE IT.

Irrespective of how much we say here, the true magic of LaserDisc can only be appreciated in person. So we've arranged for a personal demonstration in your area. Just call us at **800-621-5199**,** and we'll give you the names of the stores nearest you. Go by all means. You won't believe your eyes. Or your ears.

*Suggested retail price. Actual price set by dealer. **(In Illinois 800-972-5855).

Simulated TV picture from The Blues Brothers.

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LaserDisc

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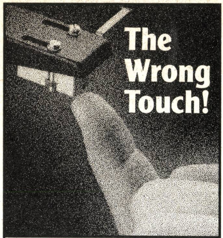

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SC-2 Fluid enhances and speeds cleaning and yet protects diamond adhesives, cartridge mounting polymers and fine-metal cantilevers against the corrosive effects of many other "cleaners".

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APRIL 1981 VOLUME 19. NUMBER 4

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COVER: Composite Photo by Fred Burrell; Saturn Photo Courtesy NASA.
Celestron C-5 Telescope Courtesy Roger W. Tuthill, Inc.

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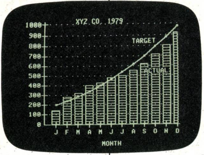

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	Apple II	Apple III
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Screen Resolution (B&W)	280 x 192	560 x 192
Screen Resolution (Color)	140 x 192 (6 colors)	280 x 192 (16 colors)
Keyboard	Fixed	Programmable
Numeric Key Pad	Accessory	Built-in
Input/Output	8 expansion slots	4 expansion slots plus built-in: disk interface RS-232 interface Silentype™ printer interface clock/calendar
Disk Drives	Add-on one to six drives	One drive built-in, plus interface to support three more drives
Languages	BASIC Fortran 77 Pascal Assembly Pilot	Enhanced BASIC Fortran 77 Pascal Assembly
Typical Configuration Pricing *Suggested retail price.	CPU, 48K RAM, single disk drive, B&W Monitor (9″), Silentype™ printer, and BASIC. **$2875.00***	CPU, 96K RAM, integrated disk drive, B&W Monitor (12″), Silentype™ printer, SOS, Enhanced BASIC. **$4865.00***

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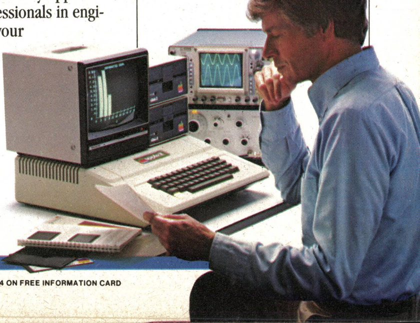

CIRCLE NO. 4 ON FREE INFORMATION CARD

EDITORIAL

Babel Revisited

Sometimes the trip to Las Vegas for the Winter Consumer Electronics Show seems like a step into a glittering, magic world in which all manner of strange and wondrous things happen, almost as in a dream. At the end, one finds oneself suddenly awake (though slightly dazed), wondering what it all meant.

This year, the rush of radically new technology seems to have slowed somewhat, and the overall emphasis fell, by and large, on new marketing concepts and, in some cases, stunning new cosmetics. Underlying all of this, however, there appear to be some new and continuing trends, one of which is highly disturbing.

The electronic marketplace, as it condenses into shape for the 1980s will encompass: three video cassette systems, three video disc systems, three digital audio disc systems (related in various ways to the video disc systems), at least four tape companding formats and three types of encoded phonograph discs. And that does not even begin to look at the confusion in the computer market, where a consumer who buys and interconnects equipment supposedly designed for compatibility (S-100, anyone?) will be lucky indeed if it works properly. And then consider the proliferation of noncompatible BASICs, and the other programming languages that spring up like so many dandelions. Such a state of affairs certainly does not promote confidence among consumers, who must not only match their needs to what is available, but also take a gamble on which of several competing systems will finally win.

A look at recent history shows that, when technology has been settled early in its development, the industry has prospered, with manufacturers competing not to see whose system would do best, but who could produce the *established* system at the lowest cost and with the most desirable features. A case in point is the compact cassette, for which Philips, the licensor, went to great pains to ensure compatibility of hardware and software, regardless of manufacture. The market strength of the compact cassette has let it withstand challenges from competing formats with ease.

FM stereo is another example. Imagine the chaos that would result if different stations encoded their signals in different ways, forcing the consumer to buy matching decoders that would not work for all. Rather than proving a handicap to industry or consumers, standardization in this case has proved a boon to all. And in no way was competition and free enterprise thwarted.

For a dismal example of the contrary situation, quadraphonics comes to mind. Here there was no standardization, and to enjoy all the competing formats, a music lover needed no less than three separate decoders. That new and improved decoders were being offered, seemingly on a monthly basis didn't help matters, either. Not surprisingly, many consumers waited for the smoke to clear before buying. Of course, the smoke had been coming from the funeral pyre of quadraphonics itself all along.

Clearly, there is a lesson here. For product categories to disappear because they cannot be introduced to market in an orderly fashion is a disservice to consumer and industry alike. There must be a better way.

Hal Rodgers

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The recording heads on your diskette drives may be dirty—and that can cause you a lot of grief. There's the serviceman you have to call when the machine doesn't perform. (You know how much service calls cost these days!) There's machine down-time. Idle data entry clerks. All the other delays a cranky machine can cause.

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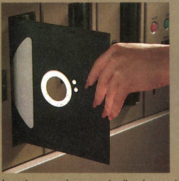
The Scotch® head-cleaning diskette kit lets you clean the read-write heads on your 8″ or 5¼″ diskette drives. In just 30 seconds, without any disassembly, mess or bother, the heads can be completely cleansed of dirt, dust, magnetic oxides—all the things that can get into your machines every day. And foul them up.

Just saturate the special white cleaning pad in its jacket with the cleaning solution. Then insert the jacket into the diskette drive and turn it on. Your machine does the rest. The heads are microscopically cleaned without wear, without abrasion.



This 3M head-cleaning diskette kit has been evaluated and approved by major diskette drive manufacturers. It's the best possible way to clean your heads without service calls or machine teardowns.

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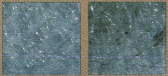


A Scotch cleaning diskette shown before use, and after 15 cleanings of recording heads.

(Not yet available for Burroughs Mini-Disk II, Vydec or 96 TPI Drive.)

3M

CIRCLE NO. 53 ON FREE INFORMATION CARD

LETTERS

Clearing Up Heat Transfer

In the interesting article, "Check Your Heat Loss with a Degree-Day Meter" (September 1980), there are two misleading statements. First, the author says "The temperature of an object is a function of the heat energy it contains. . ." Actually, an object can no more contain heat that it can contain work; heat is a form of energy in transit. We usually use the term "internal energy" rather than "heat energy."

Second, he says, "Unless artificial means (e.g., refrigeration) are used, heat always flows from a warmer reservoir to a cooler one. . ." The implication seems to be that, when we use refrigeration, heat flows from cold to warm. The refrigerator will not transfer heat unless it is plugged in. The quantity of heat transferred from hot to cold at the original heat engine to produce electricity to run the refrigerator was far greater than the amount of heat the refrigerator transfers from cold to hot; hence the net flow in the system is from hot to cold.

In the context of the article, these are rather nit-picking points, but hopefully readers interested in degree-days may also be interested in the thermodynamic aspects of energy (e.g., why it may be unwise to use an energy form with a lot of available work, like electricity, for resistance heating of homes).—*John Lord, Editor-in-Chief, Energy '80.*

Super Music Maker

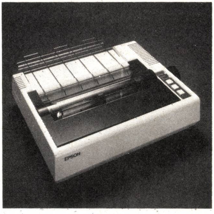
There are some ambiguities in "Build a Super Music Maker" in November 1980 Popular Electronics. I cannot reconcile the Parts List descriptions of *C2* and *C3* with the components shown in the schematic diagram. Also, in high-power versions, transistors *Q5* and *Q6* are to be removed and the speaker connected directly to the +12-volt line. What happens to the wire from *D6* to *Q5*? Is it not supposed to be used?—*Alfred Leger, Leominster, MA*

Capacitor C2 *should be a 1000-μF, 10-volt, radial-lead component. It is connected in parallel with zener diode D7. Capacitor C3 should be a 220-μF, 25-volt, radial-lead component. It is connected between the anode of D2 and ground. Note that the connection between the positive side of C1 and the cathode of D1 was inadvertently omitted from the schematic diagram. For high-power operation, simply remove Q5 and Q6 and install the insulated jumper as described in the article. There is no "wire" between the cathode of D6 and the base of Q5. There is a printed-circuit foil, however. It is not necessary to cut this foil when modifying the project to provide for high-power operation.*

OUT OF TUNE

In the "Gating Circuit Quiz" (February 1981, p 78), due to a drafting error, the answer for diagram No. 1 is incorrect. With the diagram as shown, the output would be zero. The answer is correct as given if the rightmost gate in the diagram is an OR instead of a NOR.

POPULAR ELECTRONICS welcomes comments from its readers. However, queries can be individually answered only if they are accompanied by stamped self-addressed envelopes. Please do not telephone.—Ed.



The printer you always wanted but could never afford, now you can afford. Epson.

The most revolutionary thing about the Epson MX-80 isn't the bidirectional printing or the logical seeking function. It isn't even the disposable print head—although that's pretty revolutionary. The most revolutionary thing about the MX-80 is the price. How, you may ask, could a printer that does as much as the MX-80 cost less than $650?

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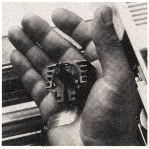

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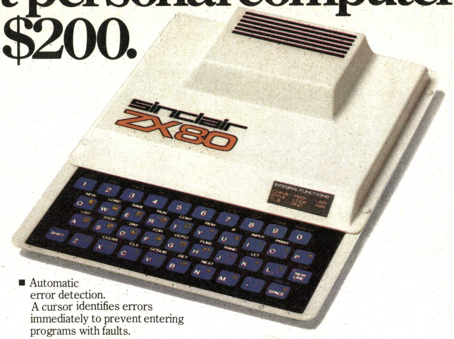

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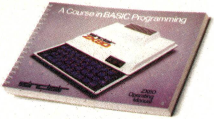
Yet, with all this power, the ZX80 is easy to use, even for beginners.



Your course in computing.

The ZX80 comes complete with its own 128-page guide to computing. The manual is perfect for both novice and expert. For every chapter of theory, there's a chapter of practice. So you learn by doing—not just by reading. It makes learning easy, exciting and enjoyable.

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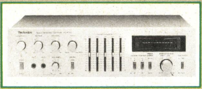
PE-4-1

NEW PRODUCTS

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Free Information Card or write to the manufacturer at the address given.

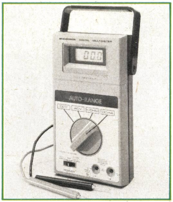
Technics Space Dimension Controller



The Model SH-8030 "Space Dimension Controller" from Technics is designed to allow you to tailor your acoustical environment or the character of individual pieces of music to your taste. It has a five-band (60-Hz, 240-Hz, 1-kHz, 4-kHz, 16-kHz) graphic equalizer, controls for mike mixing, bucket-brigade delay (BBD) electronic echo, and disc-jockey console effects fade controls. It is also said to electronically expand the stereo image to a maximum of 240° with only two speakers. A dimension and signal-level display changes according to the dimension selected and can be used as a fast-responding, 5-dB-step signal-level indicator when the dimension controls are not being used. The controller connects to the tape jacks of an amplifier, but it has jacks on its rear apron to restore the tape-monitoring facility to the system.

CIRCLE NO. 89 ON FREE INFORMATION CARD

Micronta Autoranging DMM



The Micronta digital multimeter (Cat. No. 22-196) from Radio Shack offers the convenience of automatic ranging and the low power consumption of a 0.4" liquid-crystal display as well. Designed to measure up to 1 kV dc, 500 volts ac, 200 mA dc, and 2 megohms, the DMM has a rated accuracy of ± 1 digit, with a useful bandwidth of 15 kHz for ac volts. All ranges are overload protected. Functions are selected via the only rotary control on the instrument. A slide switch, the only other control, defeats the autoranger and "freezes" scaling. Indicators show when a measurement is out of range and when the battery is low. The DMM requires a 9-volt battery or ac adapter. Size is 6⅞"H x 3⅞"W x 1⅝"D. $99.

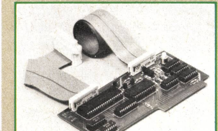
CIRCLE NO. 91 ON FREE INFORMATION CARD

Percom Speech Driver

Percom Data Co. has announced availability of an advanced speech driver and eight "talking" game programs for the company's "Speak-2-Me-2" interface. The driver routines and games are on diskette. The Speak-2-Me-2 printed-circuit card installs in a Texas Instruments "Speak & Spell." By providing the interface between the Speak & Spell and a computer, it allows the user to add speech to business and game programs. The module and software are configured for a TRS-80 Model I or II computer, but they can be adapted for other computers. The driver program provides a routine for outputting words and phrases of the Speak & Spell vocabulary and includes routines that create new words using syllables from Speak & Spell words, plus a routine to modulate the speed at which words are spoken. Included among the games are Hangman, card and dice games, and a version of Simon Says. The speech driver and games diskette are priced at $29.95, Speak-2-Me-2 adapter plus TRS-80 cable at $69.95.

CIRCLE NO. 92 ON FREE INFORMATION CARD

SSM Serial/Parallel Interface For Apple II Computers



SSM Microcomputer Products' AIO enhanced serial and parallel interface is designed for use with the Apple II microcomputer. It provides expanded capability to interface with a broad range of peripherals, including printers, plotters, terminals, modems, and other computers. It can also interface with both serial and parallel devices simultaneously when operated under Pascal. The RS-232 serial port has three handshaking lines (RTS, CTS, DED), and eight standard baud rates from 110 to 9600, including 134.5 baud for IBM Selectrics. Additional baud rates are possible through external input. The two bidirectional 8-bit parallel ports provide four additional interrupt and handshaking lines and programmable interface configurations. $225 assembled and tested, $175 kit. Address: SSM Microcomputer Prod., 2190 Paragon Dr., San Jose, CA 95131.

Buscom Tone Dialer

The Soft Touch 2 tone encoder from Buscom Systems, Inc., lets you inexpensively add convenient tone dialing to a standard telephone equipped for rotary dialing. The Soft Touch 2's pushbutton keyboard has pyramidal-shaped keys that allow easy dialing even with large fingers and long fingernails. Installation is simple: just remove the mouthpiece from the standard handset and replace it with the Soft Touch 2. $39.95. Buscom Systems, Inc., 4700 Patrick Henry Dr., Santa Clara, CA 95050.

RKO Videotape Color Filing System

RKO Tape Corp. has devised a new color-coded filing system for home videocassette

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libraries, designated the RKO ColorCode. The system is derived from a filing method used by RKO Radio in its broadcast operations. Each RKO ColorChrome videocassette is supplied with nine pressure-sensitive labels, each a different color for nine general categories—movies, sports, news, documentaries, education, drama, music, comedy, and specials. These chromium-dioxide videotapes are a new entry to the market and are available in both Beta and VHS formats.

CIRCLE NO. 93 ON FREE INFORMATION CARD

Boston Acoustics Speaker System

Boston Acoustics' Model A150 is a three-way speaker system with a 10″ acoustic-suspension woofer, 4½″ midrange driver with ferrofluid, and 1″ soft dome tweeter, also with ferrofluid. The 8-ohm speaker system has a rated frequency response of 30 to 25,000 Hz ±3 dB, with crossovers at 550 Hz and 3 kHz. Sensitivity is rated at 90 dB SPL at 1 meter with 1-watt input. Cabinet size is 30½″H x 16½″W x 8″D with a pedestal for floor placement.

CIRCLE NO. 94 ON FREE INFORMATION CARD

Metz Amateur Radio Antennas

Metz Communications Corp. has announced a complete line of amateur-radio vhf and uhf stainless-steel antennas, hardware, and low-loss RG-8/X coaxial cable. Stainless-steel coils are designed for each group of amateur frequencies, from the 10-meter band through 450 MHz. All antennas will mate with any ⅝″ x 24 threaded connector with SO-239 configuration. Magnetic, through-vehicle, and other types of mounts are also available. Coils are rated for 250 watts of input power over extended periods. Address: Metz Communications Corp., Corner Rts 11 and 11C, Laconia, NH 03246.

Nikko AM/FM-Stereo Receiver

Nikko Audio's Model NR-1000 65-watt/channel (no more than 0.03% THD, both channels driven 20 to 20,000 Hz) AM/FM-stereo receiver uses quartz synthesized tuning with a digitally generated numeric frequency display and up/down scanning. Up to six AM and six FM stations can be programmed in memory for instant recall. The preamplifier includes a head amp for low-output moving-coil phono cartridges as well as a standard phono input. Two tape monitors allow bi-directional dubbing. Power output can be monitored on paired seven-section LED bar graphs, calibrated from 0.01 to 65 watts. The dc power-amplifier section has sophisticated electronic protection for the output transistors and speakers. Size is 17.3″W x 15″D x 4.7″H. $620.

CIRCLE NO. 95 ON FREE INFORMATION CARD

Sabtronics 1-GHz Counter

Sabtronics Model 8000B frequency counter has a rated 10-Hz to 1-GHz range, with worst-case sensitivity of 30 mV. It offers nine-digit resolution; separate 1-megohm/100-pF and 50-ohm nominal inputs for 10 Hz to 100 MHz and 100 MHz to 1 GHz, respectively; 0.1-, 1-, and 10-second gate times; 10-MHz crystal time base with ±1 ppm temperature stability from 0° to 40° C; and battery operation (four C cells). It can also be powered by an optional Ni-Cd battery pack and/or ac adapter. Maximum resolution is rated at 0.1 Hz on 10-MHz range, 1 Hz on 100-MHz range, and 10 Hz on 1-GHz, all with 10-s gate time. Measurement accuracy is 1 Hz + 1 digit + time-base error. Size is 8″W x 6½″D x 3″H, and weight is 1.3 lb, not including battery. $199. Model 8610B ($129) has the same features but a high-frequency limit of 600 MHz.

CIRCLE NO. 96 ON FREE INFORMATION CARD

Heathkit Circuit-Board Course

With the Heathkit/Zenith Educational Systems Model EI-3134 Printed Circuit Boards Course, electronics hobbyists can learn how to make their own pc boards. The course uses a self-teaching textbook and explores the various aspects of pc design and fabrication in a learn-by-doing approach. To this end, the text is supplemented by course experiments, all materials for which are included. These materials include an etch-resist pen, dry transfers, art tape, etchant, and plastic bags to make direct-pattern pc boards plus a positive pattern, clear acetate, and photographic developer to make boards by the

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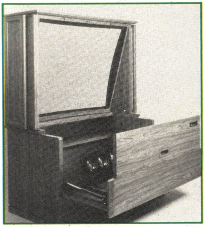
Mitsubishi Projection TV Receiver



Mitsubishi's Model VS520U one-piece 50″ projection TV system features dual amplifiers and speakers for stereo sound, screen brightness rated at more than 200 foot lamberts, and 105-channel capability. Supplied as part of the system is a full-function remote controller. The three-tube in-line system has a washable screen and four-element f 1.2 glass lenses. The unit also has a comb filter in the video-amplifier section and additional jacks for external speakers. It is available in two versions: Model VS-520U for $4,200, and Model VS-520UD, with doors that close over the screen for $4,500.

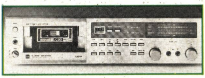
CIRCLE NO. 97 ON FREE INFORMATION CARD

A-T Ultralight Stereophones

Audio-Technica's Model ATH-0.5 ("Point 5") ultralight stereo headphones are designed especially for low-powered radios and tape players often used by joggers, skiers, bikers, and beach-goers. According to the company, the phones employ drivers with very light samarium-cobalt magnets and thin polyester film diaphragms to produce unusually lightweight drivers with improved transient response and lower distortion. Acoustical foam earcushions, a padded stainless-steel headband, and a lightweight Y cord that connects to both earcups are said to ensure proper fit. Rated frequency range is 25 to 20,000 Hz, and impedance is 4 to 16 ohms. Weight without cord is 1.9 ounces. $79.95.

CIRCLE NO. 98 ON FREE INFORMATION CARD

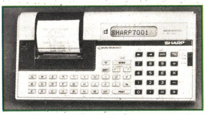
Dual Auto-Reverse Cassette Deck



Dual's Model 828 automatic-reverse deck features an exclusive lock-and-load system that provides open access to cassettes. The deck is designed to accommodate all tape formulations, including metal, via switches that simultaneously set bias and equalization. The transport features solenoid-activated controls, a four-point tape-guidance system, and two dc servo motors with integral frequency generator. Photoelectric sensors across the light well halt tape motion whenever the light beam is interrupted. A handy one-button RECORD system eliminates the need to press RECORD, PLAY, and PAUSE. Peak-indicating LED "meters", bidirectional memory wind, Dolby noise reduction, and a multiplex filter round out the deck's features.

CIRCLE NO. 99 ON FREE INFORMATION CARD

Sharp Memowriter Calculator



The Model EL-7001 "Memowriter" calculator from Sharp incorporates the functions of a miniature typewriter that prints alphanumerics on a built-in printer. The pocket-size Memowriter has a 10-digit liquid-crystal display that can be used independently of its 16-character/line impact printer. As many as 48 characters can be retained in memory. Each of the typewriter's 40-word memories can hold seven letters and 10 numerals or 15 letters. The printer automatically switches to a new memory when one becomes full. Basic functions like plus constant, chain calculations, reciprocals, powers, percentages, and roundoffs, are featured in the calculator portion of the Memowriter. Also included are a four-key memory and fixed/floating decimal-point selection, soft carrying case, and paper roll. $129.95.

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ENTERTAINMENT ELECTRONICS

By Ivan Berger

A Little Traveling Music

YOU KNOW a product's hot when everyone jumps on the bandwagon. Sony's Walkman is a good example. It's only been on the market for a year or so, yet at least 20 other companies (Caprice, Cybernet, Craig, Emerson, GE, Guardian, Gustronic, Infinity, KLH, Liberty, Mona, Panasonic, JC Penney, Randix Audiologic, Sanyo, Soundtripper, Technidyne, Toshiba, Unisef, and Yorx) are bringing out similar small, headphone-only portable stereo cassette players. Six companies (Sony, Mura, Technidyne, Caprice, Unisef and Alaron) are bringing out FM-stereo radios in similar form. Sony, Aiwa, and Technidyne have introduced ultra-compact, portable stereo recorder/players. And Panasonic will be introducing a radio/recorder combo.

All these mini-portables share the same basic concept: that a stereo system can be small if it doesn't use speakers. Headphones give stereo in a small space, and can be driven adequately by milliwatts of power. The breakthrough was Sony's development of ultra-miniature, ultra-light headphones with good sound and high efficiency.

Headphones isolate you from ambient sound, so Sony's Walkman has a "Hot Line" button that switches on a built-in microphone and cuts the music level, so the headphone wearers can hear what's being said to them. Most other pocket portables have this feature, too. Sanyo's M5550 turns the mike on but leaves the music at full volume, so you can sing along with it. The main exceptions are GE's Stereo Escape (which cuts the volume, but has no mike) and the Aiwa and Sony recorders, whose mikes are strictly for recording.

Sony's TPS-L2 Stereo Cassette Player

I recently had a chance to compare the Walkman with six other stereo players (the GE Stereo Escape, Panasonic RS-J3, Randix Audiologic Soundaround, Sanyo M5550 Sportster, Technidyne HPS-100 Hip-Pocket Stereo, and Toshiba KT-S2), as well as the Aiwa and Sony recorders, and Sony's "Mystereo" radio. They follow the Walkman's basic concept, most adding details of their own.

Some are truly pocket-sized, and weigh less than a pound (including batteries but not the headphones). The Randix, Panasonic, GE and Panasonic players and Sony's TCS-300 recorder were noticeably heavier, though, at 1¼ to 1½ pounds. They (and the Toshiba) were also a bit big for most pockets.

Headphone connections in these machines use a miniature 3.5-mm, three-conductor jack and plug. Usually, there are two headphone jacks, so you can share the fun. The Toshiba, the Panasonic and the two recorders only have one headphone jack, but the Panasonic also has two RCA phono-type output jacks to feed sound into your hi-fi system . . . albeit at microphone, rather than line, level.

Cue and review, which let you monitor the tape chatter in fast-winding modes, are included in most units. Sanyo's M5550 also has AMSS, which senses the spaces between musical selections; when it hits one during fast-wind, it stops. The Sanyo also has a pitch control, to vary tape speed up to ±6%, if precise pitch is important to you. The Panasonic, Sanyo and Randix have only one volume control and no balance adjustment. The others have two, save for the Aiwa which has separate volume and balance controls.

All the units I've seen have some kind of tone control—usually a two-position switch, but continuous controls are used on the Randix and the Sony recorder. Since almost none of these units has Dolby (a real pity) and since response from CrO_2 and ferric tapes differ so much, you'll need those switches when you change tapes. Some of these switches are marked "equalization" instead of "tone." Toshiba has one switch of each kind, with the "EQ" switch working only on tape.

What does the other tone switch work on? FM radio. The Toshiba comes with a clever FM tuner—stereo, of course—in a cassette shell. It only works in Toshiba's KT-S2 player, which provides the necessary contacts and switching, feeds power from its own batteries, and has a slot in its tape-compartment door for the tuning thumbwheel. The tuner also has a mono/stereo switch and stereo indicator LED, too. KLH and Infinity will have similar (not identical) models, with Dolby noise reduction on Infinity's version.

Both the Toshiba cassette and Sony's pocket radio use their headphone cords as FM antennas (Sony's Mystereo radio has AM, also—Toshiba reportedly offers a separate AM cassette in Japan, but not here). Both are pretty sensitive, too: I picked up some New York stations on a Connecticut hilltop about 90 miles away.

Not all the differences between these portables show up in spec sheets, though: they neither sound nor feel alike. The main sonic differences were in wow and flutter, and in frequency (especially treble) response. And control feel and layout varied considerably.

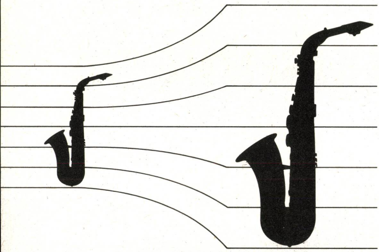
Using a Nakamichi T-100 Audio Analyzer, I measured wow and flutter on these units. It was lowest on the two recorders (0.25% for the Aiwa, 0.15% for the Sony), where low wow and flutter matters most. The others were mostly around 0.3%, which is about as much as I feel comfortable with. The Sanyo and Technidyne had 0.35% wow and flutter, which begins to bother me, and the Randix had 0.4%.

Frequency response seemed to depend less on the decks themselves than on the headphones you plug into them. The Sony MDR-3L2 sounded best to me, with the Aiwa phones just a hair behind them. All the phones sounded pretty good and were reasonably comfortable. The GE and the bright-sounding Sanyo phones, whose drivers swivel slightly, were especially comfortable. Most of the rest had angled headbands (which made them uncomfortable if you put them on backward), but they could be bent somewhat for custom fit. Technidyne's phones also folded in the middle, for more compact carrying. And the Randix phones were noticeably more efficient than those from Sony.

Miniature headphones are becoming available for home use too. Sony foresaw that, when they packed a quarter-inch jack adapter with their MDR-3L2 phones, and Mura, Pickering and Audio-Technica have since brought out lightweight phones with quarter-inch plugs. Pickering supplies an adapter for the pocket system's 3.5-mm jacks, and Audio-Technica makes a 3.5-mm plug standard on their Point-1 phones, in contrast to the quarter-inch-plug Point-3 and Point-5 models. Koss has a folding model with 3.5-mm stereo plugs plus adapters for 3.5-mm mono and ¼″ stereo jacks.

(Continued on page 20)

How to get 50% more sound without turning up the volume.



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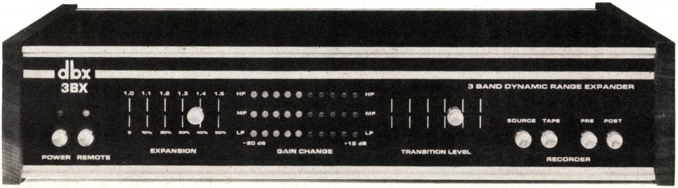

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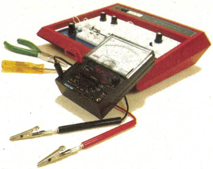

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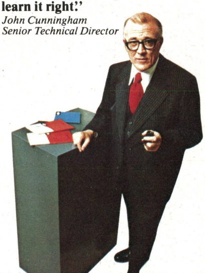

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(Continued from page 14)

Recorders and Radios. Of the two miniature stereo recorders, the Aiwa TP-S30 was most like the Walkman-style players in its size and weight. It has a built-in, monophonic mike; if nothing else is plugged in, it will feed both channels. Plug a mono mike into the left-channel mike input alone, and it, too, will feed both channels—but if you plug that mike into the right input instead, it will feed only the right channel, while the built-in one will feed the left. External stereo mikes (such as Aiwa's nice little $36 electret one) plug into both inputs. A flick of a switch, and the jacks become line-level, Aux inputs—only be careful to set it properly, since it doubles as the tape equalization selector during playback.

The Sony TCS-300 was considerably bigger, but had a few more things built in: a loudspeaker, for monophonic playback; a monophonic earphone jack (in addition to the stereo headphone one); and a built-in stereo microphone. Jacks are provided for external mikes, too, and there's a Pre-End alarm LED, to warn you shortly before the tape runs out.

Both made recordings of about equal quality—I can't tell which I'm listening to. Both did their best on standard-bias, 120-microsecond ferric tapes, but could also record quite well on chrome or chrome-equivalent ones though with a bit more hiss in the latter case. To me the Aiwa's more convenient size outweighed the Sony's extra features. But it could have benefitted from the use of a clip to hold the stereo mike (as it is, recording in stereo requires either two hands or one hand plus a pocket), and a tiny speaker for emergency playback.

Sony's Mystereo radio was the most compact and the best sounding portable—it seemed to have wider frequency response and (on strong signals) less noise than any of the tape systems, and of course it was immune to wow and flutter. The $220 radio system also includes a 2-speaker box into which the radio slides for stereo listening without phones. The box also has its own power source (four C cells) and a jack for a power supply, plus a jack for playback from a Walkman or similar player. The box can sit on a table or hang from a shoulder strap. The speakers, though, don't sound as good as the headphones, and the stereo effect is only perceptible when you're close to the speakers.

Compact as all these pocket systems are, there's more compact equipment right around the corner. Several similar systems using microcassette tapes were shown in Japan last Fall. Fisher showed one in January, and Aiwa has one that also records from its built-in AM/FM tuner. I wouldn't expect to see many in the stores for several months, however. And microplayers won't do you much good unless you have a microcassette stereo deck to make tapes with. Prototypes of such decks have been shown, though, by Olympus and Fisher; and Fisher has announced that its will be available soon. ◇

AUDIOPHILE RECORDINGS

By Harold A. Rodgers
Executive Editor

ALTHOUGH the mainstay of the audiophile recording market has, of course, been the vinyl phonograph disc—and this is not expected to change markedly in the near future—high-end prerecorded cassette tapes are beginning to appear. Mobile Fidelity Sound Labs, for one, is introducing such a line (recorded in real time on BASF chromium dioxide) for just under $18 per cassette. These Original Master Recording High-Fidelity Cassettes, like MFSL's discs, are prepared from leased master tapes.

Prerecorded cassettes are also available from dbx—encoded, of course, and claiming a dynamic range in excess of 80 dB. Offered at a retail price of $20, these are also recorded on chromium dioxide. Source material, which includes some digital master tapes, is drawn from recording companies now participating in the dbx encoded disc effort. The same decoder, incidentally, works for discs and tapes. Duplication (in real time) is provided by In Sync Laboratories.

But the most exotic prerecorded cassettes to date will come from AudioSource and are recorded on JVC metal particle tape. Prices will vary between about $15 and $30, depending on the individual release.

Enter the UHQR. Soon to be available from Mobile Fidelity is the Ultra High Quality Record. Manufactured, according to MFSL's Gary Giorgi, from the same metal parts as the company's regular releases, this disc starts out with a 200-g slug (185 g after deflashing) of vinyl and a five-minute pressing cycle. This means a maximum of 12 discs per hour per press. UHQRs will be individually numbered and sold to collectors at $40 each.

On the basis of what can be heard from a test pressing, these discs are about as quiet as MFSL's regular production—which is very quiet. Their special quality lies in an excellent sense of depth and articulation. This, says Giorgi, results from the fact that at 3 mils the grooves on these discs are twice as deep as those on standard audiophile discs. The superior control of stylus motion thus afforded reduces minor mistracking—rarely audible as such, but deleterious to sound quality in any case—to very low levels. ◇

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Audio Product of the Month

CHOSEN BY THE EDITORS OF POPULAR ELECTRONICS

Yamaha T-7 FM/AM Tuner

Motor-driven tuner has preset memories for 5 FM and 5 AM stations

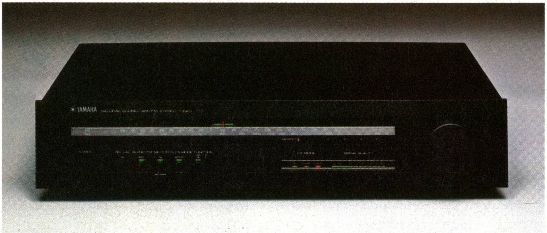
SEVERAL years ago, the Yamaha CT-7000, one of the early "super" FM tuners, set new performance standards for its time. The T-2, a later, less expensive model, earned an enviable reputation among audiophiles. Much of the technology of the CT-7000 and T-2 has now been brought into a more affordable price range in the new Yamaha T-7 FM/AM tuner.

Features of the T-7 include preset memories for 5 FM and 5 AM stations, automatic motor-driven tuning, and excellent distortion and S/N ratings. Finished entirely in black, the unit measures 17⅛" W x 13⅛" D x 3¾" H, and weighs 11½ pounds. Suggested retail price is $400.

General Description. FM tuners have not kept pace with the vanishingly low distortion and noise of amplifiers. Technological limitations are part of the cause as is the fact that FM broadcast standards and practical difficulties (such as multipath effects) would render much of the effect of such performance moot.

However, Yamaha's philosophy is to make its products as competent as possible, within the constraints set by the market. In the case of the T-7 tuner, balance between tuning convenience and noise level has been sought, without undue sacrifice elsewhere. This necessitates adjustment of operating parameters, manually and automatically, to optimize performance under different receiving conditions.

Yamaha rejected digitally synthesized tuning in this case principally because the circuitry required tends to raise the background noise level of the tuner. Also, to make the large number of varactor-tuned circuits needed for the desired image rejection would be difficult and costly. Therefore, a conventional capacitor-tuned front end was chosen. To offer the convenience of preset tuning channels, Yamaha used a motor-driven tuning capacitor, combined with a digital memory. The motor turns the capacitor until it is very close to the stored setting, after which an analog servo system (operating from a discriminator output voltage) fine tunes to the exact station frequency. The afc (which Yamaha calls OTS, for "Optimum Tuning System") remains in effect constantly. A full scan over the FM band requires about 12 seconds. While the tuner is scanning, a touch on the tuning knob instantly disengages the motor



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"Major VHF channels were received with uniformly accurate color fidelity. This receiver produced superior color pictures even when using its own indoor VHF and UHF antennas."

"The special tuning features and remote control capabilities of the Magnavox receiver are awesome."

"The tuning system is purely electronic and totally digital," they continue. "There is a fine tune switch and a memory lock button. If any channel is received mistuned, the user simply fine tunes up or down in frequency by holding the button, and when perfect tuning has been achieved, the button is released and the memory lock button is depressed once.

"Nearby is Magnavox's Videomatic feature. Depressing this button activates the electronic eye for automatic brightness adjustment, color adjustment circuits and automatic fine tune."

"...unusually good for any receiver."

Overall, *Video Review* rated the Magnavox 9.5 or better (out of a possible 10.0) on Video Quality, Reception Sensitivity, Color Fidelity, and Video Resolution and Fidelity. As they put it, "...unusually good for any receiver."

We can only add that once you see a Magnavox color TV at your Magnavox dealer, we think you'll agree.

For Magnavox color TV specifications, write Magnavox Consumer Electronics Company, Dept. 700, P.O. Box 6950, Knoxville, Tennessee 37914.

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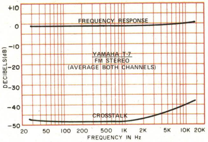
drive and restores manual tuning simultaneously disabling the OTS. OTS returns automatically a couple of seconds after the knob is released.

Although the tuning of the T-7 is analog, its station memory is digital. The angular position of the tuning capacitor is converted into a 10-bit digital word that is stored in one of 10 memories in an LSI chip. The A/D conversion appears to be based on a frequency-to-voltage conversion. The memory should retain tuning locations with a resolution of about 20 kHz on FM, or 1 kHz on AM. These errors lie well within the corrective range of the OTS system.

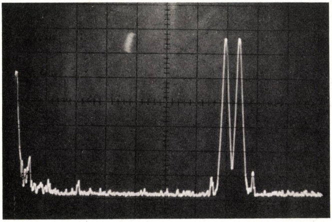
Yellow bars on each side of the dial pointer travel with it, lighting to show when a signal is nearby and which way the tuning should be shifted to reach the channel center. At the correct point, both bars light to equal brightness, becoming visibly brighter to show that the OTS is operating, after the tuning knob is released.



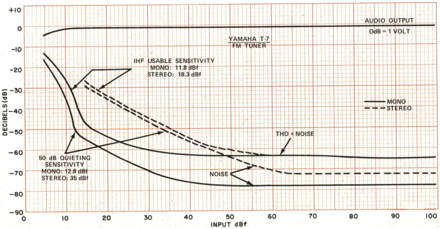
Frequency response and crosstalk.

Below the dial, a row of line segments successively light up to show relative signal strength. A red STEREO light and two green lights marked DX and LOCAL show the status of the automatic bandwidth and channel separation switching. The i-f section includes a special narrow-band stage for high selectivity. When signal power exceeds 39 dBf, the extra selectivity is bypassed, improving distortion and channel separation. An AUTO/DX switch can be used to place the tuner in its LOCAL mode regardless of signal strength.

Five small pushbuttons control the tuner's operating modes. Each is a momentary contact type that changes its assigned function (and an indicator light) on alternative operations. Switches include one for AUTO/DX/LOCAL and one, a combined FM MUTE/OTS, that disables muting and OTS, simultaneously converting the signal strength readout to a multipath display. In this mode, the signal-strength indicators are dimly lit. Multipath distortion (which creates strong amplitude modulation of the received signal) causes the low-level segments to flash to full brightness. The next switch is BLEND, with AUTO and OFF settings; it automatically reduces noise on weak stereo signals by blending the high frequencies between the two channels. Switching it off gives maximum separation at all times. A FUNCTION switch selects AM or FM reception, and a REC CAL button replaces the audio program by a tone, nominally 400 Hz, whose level is equal to 50% FM modulation, as an aid to setting levels for recording off the air. The POWER switch is a larger rectangular button that also operates in a nonlatching, momentary-contact fashion.



Spectrum analyzer photo of IM distortion with 14- and 15-kHz input tones. Zero dB equals 100% modulation at 1 kHz.



Tuner noise and sensitivity curves.

The rear apron of the Yamaha T-7 contains two sets of audio outputs, one at a fixed level and another adjustable via a knurled wheel under the front edge of the panel. Binding posts are provided for a 300-ohm FM antenna, and there is a coaxial jack for a 75-ohm antenna. The AM antenna is a hinged, removable, rectangular shielded loop that can be located anywhere within a couple of feet of the tuner.

Circuitry of the Yamaha T-7 includes a multiplex pilot carrier canceller that does not cause any loss of high-frequency response in FM stereo reception, and a highly linear wide-band ratio detector said to give lower distortion than any other type. In addition, the multiplex demodulator uses high-speed CMOS integrated circuit switches.

Laboratory Measurements. The IHF Usable Sensitivity of the T-7 in mono was 11.8 dBf. In stereo it was 18.3 dBf. The stereo switching threshold was 11.8 dBf. Sensitivity for 50-dB quieting, a measurement more reflective of real performance, was 12.8 dBf in mono and 35 dBf in stereo.

At 65-dBf input the tuner noise level was −76.5 dB in mono and −71 dB in stereo; the respective distortion readings were 0.078% and 0.073%. These measurements were made with the tuner in its LOCAL mode.

IHF-IM distortion was measured by modulating the signal generator with equal-amplitude tones at 14 and 15 kHz, whose combined peak level was equal to that of a sine-wave modulation of 100% (75-kHz deviation). The tuner output was displayed on a spectrum analyzer. Third-order IM products at 13 and 16 kHz were 57 dB (0.014%) below the primary tone levels, and the second-order difference tone component was −73 dB (0.022%) referred to 100% modulation.

Capture ratio was between 1.65 and 1.7 dB, depending on signal strength, and AM rejection was 69 to 70 dB. Front-end selectivity was exceptionally high, placing its image rejection beyond our measurement ability (>106 dB).

In LOCAL mode, alternate channel and adjacent channel selectivity were 46 and 9 dB, respectively. The former is adequate for most receiving conditions (it was perfectly usable in the New York metropolitan area) and the latter is actually better than average. In the DX mode, the respective ratings were 84 and 17 dB. Transition between DX and LOCAL modes (for both the selectivity and blend functions) took place at about 38 dBf.

The muting threshold was approximately the same as the stereo threshold, and 19-kHz pilot carrier leakage into the audio outputs was low at −68 dB. Hum was at −74 dB. When the REC CAL button was pressed, the tone delivered corresponded to 52% modulation.

Frequency response in stereo was ruler-flat from 30 Hz to several kHz, rising gradually to +1.2 dB at 15 kHz. Channel separation was very uniform—about 48 dB from 30 to 1,000 Hz, reducing to a minimum of 36.5 dB at 15 kHz.

The only measurements made on the AM section of the T-7 were of frequency response, in both LOCAL and DX modes. In LOCAL, frequency response was −6 dB at 55 and 3,500 Hz. In DX mode, the high-frequency response was −6 dB at 2,200 Hz, confirming increased selectivity for weak signal reception.

User Comment. In appearance, the T-7 is deceptively simple, considering its complex circuitry. Fortunately, its operation is simple (not at all deceptively) and free of annoying quirks.

FM muting is perfect, with the tuner totally silent until a station is tuned in exactly. Muting is effective on AM too, but only when the preset station selection is used. For anyone accustomed to the essentially instantaneous frequency transitions of digitally synthesized tuners, the relatively leisurely movement of the T-7's dial pointer when a preset button is pressed may seem amusingly anachronistic. However, unless one makes a habit of switching between stations at the opposite ends of the dial, the operation is not likely to take more than 3 or 4 seconds. This compares very favorably to the speed of manual tuning, and is considerably easier as well as more likely to be accurate. With the indication provided (the red STEREO light comes on only when the tuning is exactly correct), the user of the T-7 will enjoy low distortion in practice as well as in theory.

Many of the performance qualities and features of the Yamaha T-7 were formerly available only in very expensive "super tuners." Now the owner of a moderately priced stereo system, can have, paying only $400 for the T-7, FM performance and convenience that rival anything available. In design philosophy, the unit represents a happy marriage of the best of the analog and digital worlds. In operation and use, it is simply a pleasure. *—Julian D. Hirsch*

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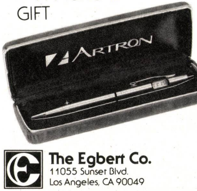

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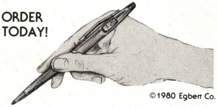

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CIRCLE NO. 13 ON FREE INFORMATION CARD

Popular Electronics Tests

Sharp 19E91 19" Color TV Receiver

SHARP's Model 19E91 is a handsome 19-inch table-model color-TV receiver housed in a walnut-grained plastic cabinet. It is equipped with a calculator-like keyboard for random channel selection, LED channel display, automatic color and balance control, and a CATV/MATV jack. Included also is an infrared remote-tuning system, also with a keypad, that operates a sophisticated 24-function microprocessor. Among the 19E91's other features are a 4-inch round speaker and a sensor that varies picture brightness according to ambient light level. Dimensions are 24³⁄₁₆"W × 19⅛"D × 17⅞"H, and weight is 51.8 lb. Suggested retail price is $739.95.

Technical Description. Beginning with the ac input in Fig. 1, the 19E91 has the usual line filter coils, followed by a conventional "hot-chassis" full-wave bridge rectifier that delivers two 80-volt (approximately) outputs to the remote-on power controller on the remote-control board and initial dc bias to the anode of thyristor *SCR701*. A return from the emitter of the power controller then turns on *SCR701*, which now becomes a half-wave rectifier that delivers 120 volts to the entire system.

When the horizontal-output transformer (HOT) "fires," *D705* and *D601* conduct and a sawtooth driving voltage reaches power regulator *I701*. In addition, the sawtooth voltage establishes +190 volts dc through *D705* for collector biasing of the red, blue, and green luminance/chroma matrix outputs into the picture tube. The 190- and 120-volt sources are filtered by series "doubler" capacitors *C706* and *C707*. Power regulator *I701* now operates with the 18-volt source, taking its reference through a potentiometer connected between the 120-volt output and ground. The power regulator controls the gate conduction of

SCR701, thus determining its on time and, hence, its current output.

Also in the primary of the *T602* horizontal output transformer are a few turns that furnish both heater voltage for the cathode ray tube and ac that is rectified and filtered to provide the threshold potential for 22-volt zener diode *ZD651*. When *ZD651* breaks over and conducts, a positive dc potential is sent to the X-ray protector in the sync processor. This voltage turns on the X-ray gate at an initial net potential of about 3 volts and kills the CRT's heater and high voltages—and the raster.

The sync processor, a 16-pin chip, extracts composite video from the luminance/chroma processor, and has an internal automatic frequency detector (afc) that regulates the horizontal oscillator frequency, provides an RC-controlled sync gate and, after the vertical oscillator, shapes a sawtooth wave for the vertical amplifier output. It also, via a flip-flop, shuts off the horizontal driver and output when there is too much high voltage, and it contains a voltage regulator.

When there is no incoming signal, a dc-operated horizontal-hold control keeps the RC-timed oscillator in approximate flywheel sync. Sharp's horizontal output stage (Fig. 1) is a conventional current-driven power transistor with shunt diode damper, in parallel with small 3- and 1.6-kV capacitors to ground. The vertical output stage consists of stacked npn transistors that deliver a sawtooth voltage through a 470-μF capacitor to the deflection coils. A side pincushion transformer corrects for any concave nonlinearities, while a variable linearity coil does the rest for horizontal sweep.

Following video detection, luminance information is routed directly (dc) to the chroma/luminance IC while chroma is inverted and LC bandpass filtered before it enters. This LSI chip processes virtually all luminance and chroma functions (except matrix outputs) for the entire receiver.

After inversion and bandpass filtering composite video is routed to the first chroma amplifier. A dc potentiometer sets gain for the contrast amplifier, which routes video information through the usual luminance delay line (D.L.) and on to the sync pedestal clamper. The degree of clamper conduction is monitored by a transistorized automatic brightness limiter (abl) and its varying reference voltage from the HOT. With black reference restored, luminance intelligence is then direct-coupled to the base of a video driver transistor and on to the emitters of the RGB matrix output amplifiers.

After amplification by the first chroma amplifier, chroma and color burst go to the burst amplifier and second chroma amplifier via the color killer, which cuts off the latter when there is no incoming chroma. A gating signal from the sync separator IC alternately turns on and off the chroma and burst amplifiers so that automatic phase control (apc) is applied to the 3.58-MHz voltage-controlled (color sync) oscillator during horizontal blanking. It also automatically controls the gain of the first chroma amplifier through the agc detector. During the line-scan period, amplified chroma goes to the RGB−Y (red, blue, and green minus luminance) demodulators, whose reference phase-control voltage is applied through the lower matrix. Demodulated outputs issue through the upper matrix to the bases of the RGB matrix output transistors.

I-f amplification and automatic gain control (agc) are provided by a single IC that also delivers automatic fine tuning (aft) and detected video. In addition, it amplifies the video signal and cancels any momentary incoming noise that would upset chroma, luminance, audio, and sync.

Uhf and vhf tuners supply sound and picture information to this IC through the i-f preamp and a surface acoustical wave (SAW) filter. The latter has sharp bandpass skirts and excellent adjacent-channel rejection. The only tunable element in the i-f circuit is an LC tank circuit for the synchronous video detector.

I-f and r-f agc voltages are developed by peak detection without flyback sync gating; tuner sensitivity is statically set by manual r-f agc control. Aft error voltage is detected and differentially amplified, then filtered and translated into dc control voltages for the tuner oscillators. High-level noise passing through is detected by the noise canceller, which cuts off video and sync for its duration. To prevent detection "tweets" and develop additional linearity, midband 44-MHz information is detected synchronously. Composite video, including sound, is developed for further chroma and luminance processing. The usual 4.5-MHz intercarrier sound develops from heterodyne action between the 45.75- and 41.25-MHz video and sound carriers. The sound carrier is first limited and amplified, and then FM detected and ac coupled to a pair of push-pull class B output amplifiers.

Tuners and their controls in this remote IR set contain complex microprocessor and logic circuitry. We can, however, give you some idea of what this part of the receiver can do.

To properly interact with the "microcomputer," each channel-select key on the front-panel and infrared remote-controller keyboards is assigned a unique 5-bit binary code. The system can be programmed to accept up to 20 channel designations, 12 vhf and eight

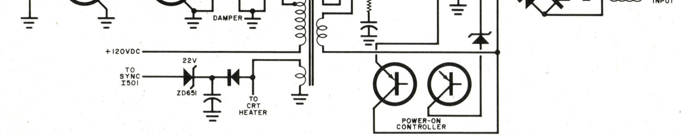

Fig. 1. Simplified schematic of the 19E91's complex power supply.

uhf. Since volume up, volume down, mute, and power are also microprocessor controlled, they too have their own unique binary-code assignments.

When a channel select key is pressed on the front panel or remote controller, its code is transmitted to the processor, which instantly accesses the desired channel and shows its actual number on a large LED display. There are no channel scan buttons. Volume up and down buttons, on the other hand, operate in a scan mode.

When the receiver is initially energized, the power-on command to the microprocessor resets tuning and sound so that the channel assigned to button 2 automatically comes on the screen and its vhf number appears in the LED display. Subsequent channel designations result in a 4-bit data transfer to the decoder and driver, programmable divider, nonvolatile memory, and decoder drivers. Appropriate frequency and display division and comparisons are made in the phase detector. The output of the local oscillator in the phase-locked loop (PLL) is divided and then directed to a buffer that acts as the clock generator for the microprocessor. At the same time a transistor selects bandswitching for low or high vhf or uhf for the prescalers and the U/V tuners.

If there is a phase difference between the local PLL oscillator crystal and command channel frequency, an error voltage from the phase detector goes to the D/A converter, whose dc reference produces an analog correction voltage. When applied to the tuners, this voltage holds them precisely on frequency. Feedback from the prescaler to the PLL programmable divider closes the loop for positive feedback control.

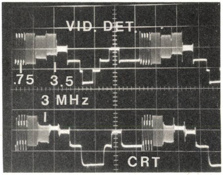

Fig. 2. Multiburst test pattern at video detector (top) and CRT cathodes (bottom).

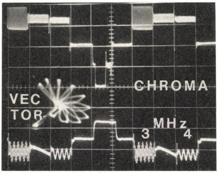

Fig. 3. Swept chroma and vector patterns from the video detector and CRT cathodes.

Uhf stations up to a total of eight may be fine-tuned into memory from the receiver's front panel and then command-executed via either the keyboard or remote control. Discrete transistors take care of the muting, volume, and on/off controls.

This Sharp receiver possesses an unpluggable chassis that is nicely laid out for servicing. The EIA312 code identifies the CRT as a Sylvania product, and the microprocessor is socket-mounted for easy removal and substitution.

Test Results. The worst voltage regulation we measured was an excellent 98 percent. Signal/noise measurement read 39.5 dB, a very good figure, and the vhf tuner field-strength reading before onset of snow was an excellent −17 dBmV (−65.8 dBm). Agc also had a wide dynamic range, from −17 to +35 dBmV (−65.8 to −13.8 dBm), a respectable swing before sync clipping at 52 dB. No CB interference was noted during our test on any channel at a distance of 60 feet between outside antennas, and pincushion/barreling effects were nonexistent.

Multiburst pattern revealed at least 3.5 MHz of bandpass at the video detector and 3 MHz at the CRT (Fig. 2). However, the 4.08-MHz swept-chroma pattern at both the video detector and CRT was slightly down, and there was some fuzzy high-frequency accumulation in the 3.08-MHz portion of the signal. The vector pattern between the two waveforms (Fig. 3) was slightly asymmetrical and flared between blue at 180° and green at 300°. There are also some overshoot spikes of voltage in both chroma displays.

Comments. In many respects, the Sharp 19E91 is a high-performance receiver with a number of outstanding measurements that place it a good cut above much of its competition. Tuner control, particularly, is excellent. Thanks to the chassis's superlative voltage regulation, we noted hardly any picture shrinkage or blooming when we varied the ac input between 95 and 135 volts. While the picture was not quite as crisp as it could have been on the sample we evaluated, it was no worse than we've experienced with other 19" models in the same price range. Picture brightness and color quality were about average. Finally, Sharp's "energy-saving" Sigma 400 chassis, rated at 95 watts maximum, should go easy on your electric bills.—*Stan Prentiss*

SHARP MODEL 19E91 RECEIVER LABORATORY DATA

Parameter	Measurement
Tuner/receiver sensitivity at 75Ω (min. signal for snow-free picture):	vhf (Ch. 3): −17 dBmV (−65.8 dBm) uhf (Ch. 40): −8 dBmV (−56.8 dBm)
Voltage regulation (line varied from 105 to 130 V):	Low voltage: 183-V supply—100% 12-V supply—99% High voltage: 24.5-kV supply—98%
Luminance bandpass at CRT:	3 MHz
Luminance bandpass at video detector:	3.5 MHz
S/N at CRT:	39.5 dB
Convergence:	99.9%
Horizontal overscan:	10%
Agc linear swing (−17 dBmV to +35 dBmV):	52 dB
Audio bandpass (3 dB down):	110 Hz to 3.5 kHz
Power requirement (signal applied):	75 W (incl. remote)

Note: Instruments used in these measurements are from Tektronix, Sadelco, Data Precision, B&K-Precision, and Sencore. They include: Telequipment D66, D67A oscilloscopes; FS-3D-VU f/s meter; Models 245, 1350, 1750 multimeters; types 1248, 1250, CG169 and VA48 (modified) color bar and signal generators; and a variable PR57 power supply.

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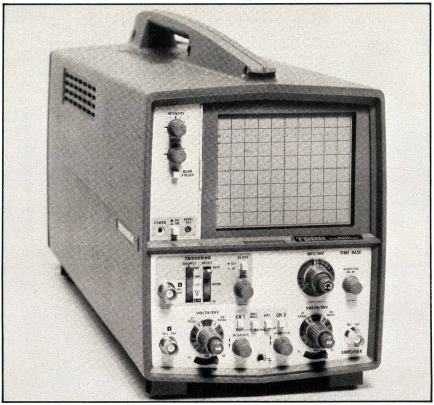
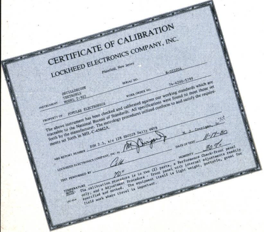
The Tektronix T922 Dual Trace Oscilloscope



THE Tektronix T922 Dual Trace Oscilloscope is a dc-to-15-MHz instrument designed for general-purpose waveform viewing. Its companion, the T922R is a more elaborate 19" rack-mounted version, and the T921 is a single-trace version. This new line of instruments, carrying the Tektronix name, is aimed at engineers and service technicians who demand a lot from a relatively low-priced scope.



CERTIFICATE OF CALIBRATION
LOCKHEED ELECTRONICS COMPANY, INC.
Plainfield, New Jersey

INSTRUMENT OSCILLOSCOPE TEKTRONIX MODEL T-922
SERIAL NO. 8-031056
WORK ORDER NO. 74-6200-5799
PROPERTY OF POPULAR ELECTRONICS

The above instrument has been checked and calibrated against our working standards which are traceable to the National Bureau of Standards. All specifications were found to meet those set forth by the manufacturer. The metrology procedures utilized conform to and satisfy the requirements set forth in MIL-C-45662A.

NBS REPORT NUMBER SUM 2.5, s/n 128 ES0528 Daily WWVB
LOCKHEED ELECTRONICS COMPANY, INC. By M J Corrigan Jr. M. J. Corrigan, Jr.
DATE OF TEST 11-17-80
TEST PERFORMED BY Cole
HUMIDITY 30%
TEMPERATURE 70°

NOTE: The calibration procedure is in two (2) parts, a Performance Check-front panel only; and a Adjustment Procedure - front panel with internal adjustments readily specified and marked. The equipment itself is light weight, portable, great for field work where travel is important.

Some of the interesting features of the T922 are a rectangular CRT with an 8-x-10-cm display area, a built-in graticule to eliminate parallax viewing error, a 12.4-kV accelerating voltage, a BEAM FINDER that locates either or both traces if the position control has taken the trace off the screen, and a tilt stand and skid-proof feet to enable use on a smooth-topped workbench.

The T922 measures 7"W x 19"D x 10"H and weighs 19 lb. Suggested retail price is $1,090.

General Description. The two vertical channels have their operating controls symmetrically arranged about the center of the front panel. Selection of either channel, or dual trace, is made via pushbuttons.

The VOLT/DIV scale of each vertical step attenuator is optically arranged so that only two ranges are clearly visible at a time—one for use with a ×1 probe, and the other for use with a ×10 probe. The VARiable input gain control, color-coded red and mounted coaxially with the step attenuator, forms a vernier between the 1-2-5 settings of the step attenuator control.

Mounted alongside each range switch is the trace POSITION control. Each vertical input (BNC type) is provided with an AG/GND/DC signal selector switch; and a separate additional ground connector is provided.

The common time base TRIGGERING SOURCE can be selected from INTernal, LINE, EXTernal, EXT/10, or X-Y (vector). The TRIGGERING MODE can be selected from AUTO, NORM, or TV. AUTOMatic

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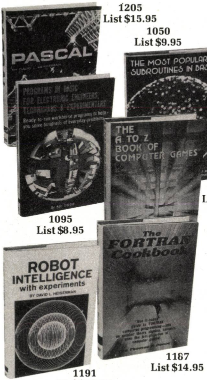
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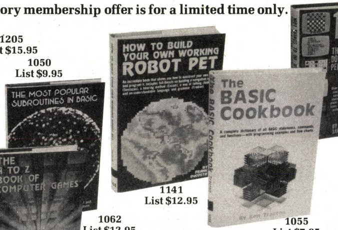
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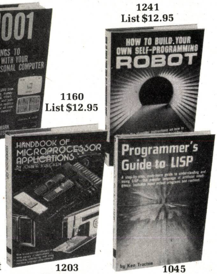
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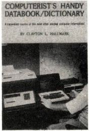

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MANUFACTURER'S SPECIFICATIONS

CRT
Display area: 8 × 10 cm (rectangular)
Phosphor: P31
Accelerating potential: 12.4 kV
Built-in graticule
Vertical amplifier
Deflection factor: 2 mV/div to 10 V/div,
12 steps, 1-2-5 sequence
Accuracy: +20°C to 30°C within 3%
0°C to 45°C within 4%
Variable range: continuous between settings.
Extends deflection factor to at least 25 V/div.
Frequency response: dc to at least 15 MHz.
Risetime: 23 ns or less
Chopped mode: approximately 250 kHz
Input impedance: approximately 1 MΩ/30 pF
Max. input voltage: 250 V (dc + peak ac)
500 V (p-p ac) at 1 kHz
Sweep Rate
Range: 0.5 s/div to 0.2 μs/div,
20 steps in 1-2-5 sequence.
Magnifier: ×1 to ×10
Accuracy (0° to +45°C): Unmagnified within 4%,
magnified within 6%
X-Y operation
Deflection factor: ×10 magnifier approximately 100 mV/div,
×1 approximately 1 V/div.
X-axis bandwidth: dc to at least 1 MHz.
Input impedance: 1 MΩ/30 pF
Phase difference between axes: 5° or less
from dc to 50 kHz.
Triggering
Sensitivity: 0.5 div internal or 100 mV external from 2 Hz to 1 MHz,
increasing to 1.5 div int. or 150 mV ext. to 15 MHz.
TV sync: composite sync 1 div internal or 100 mV external
(approximately 2.3 div or 230 mV composite video).
External trigger: max. 250 V (dc+peak ac) or
500 V (p-p ac) 1 kHz or less.
Input impedance: 1 MΩ/30 pF.
Level range: +0.5 to −0.5 V external,
+5 to −5 V external/10.
Power: 120/240 V, 50/60 Hz, 50 watts.
Environmental
Storage temp: −55 to +75°C,
Operating temp: 0 to +45°C,
Altitude: 50,000 feet.
Physical
Weight: approximately 15 lb.
Width: 7.09 in.
Height (to top of handle): 10 in.
Depth: 18.7 in.
Accessories: 2 probes, clear filter, manual.
Optional Accessories: plain and rainproof covers, stand,
1× probe, switchable 1×-10× probe,
100× probe, 1000× probe,
ac current probe, 10× dc to 35 MHz probe.

trigger syncs the sweep in accordance with the preset switches, NORMal means manual adjustment of the triggering, while TV selects an internal TV-like sync clipper as the source of sync pulses. This latter position is useful for TV servicing. Trigger SLOPE can be either positive or negative, with the triggering point determined by the LEVEL control.

Like the vertical attenuator, the time base SEC/DIV switch is also arranged so that only the range in use can be easily read. Coaxial with this switch is a red-colored knob that allows sweep time magnifications from ×1 to ×10 between each step-switch setting. This latter control is used in place of the usual fixed sweep magnifier.

Mounted on the rear of the chassis, the Z-axis connector can be used to modulate the intensity of the traces with a positive-going signal causing a decrease in trace intensity. Discretely molded into the front panel are a series of slots for an optional camera or protective front panel cover. Each of the two P6006 Probes that come with the T922 are of the ×10 type, having an input resistance of 10 megohms, and a voltage rating of 600 volts dc, or 600 volts ac peak-to-peak and dc combined.

Accompanying each probe is a 12″ and 5″ ground lead having an alligator clip, a plastic probe holder, BNC tip, banana plug, probe tip hook, spring tip, and a pincher tip. The last five items screw onto the probe.

Probe compensation is accomplished by connecting the probe tip to the scope front-panel PROBE ADJ connector, loosening the probe locking sleeve, then twisting the probe body until a clean square wave is displayed. After compensation, the locking sleeve is tightened.

The manual accompanying the T922 is impressive and contains everything you need to know for initial start-up, adjustments, service, etc. It is profusely illustrated and contains complete schematics, board interconnections, and a detailed parts list.

Comments. The manufacturer's own specifications for the T922 are shown in the Table. The instrument was checked by the Lockheed Instrumentation Measurements Lab., against standards traceable to the Nation Bureau of Standards. The lab issued a certificate testifying that the T922 meets or exceeds its claimed specifications in all respects.

We found the T922 very easy to use, with all controls clearly identified. At first, the small knobs felt a little uncomfortable, but we soon got used to them. Triggering quality was excellent, even on very short duration waveforms. Even after several hours of use, the scope ran cool.

The only flaw we found was a trace "ghost"—a faint defocussed image that accompanies each trace and produces a faint background haze. Tektronix informed us that this "ghosting" is due to the use of 12.4 kV on their post acceleration CRT, as compared to the 2 to 3 kV usually used in scopes. This very high voltage gives the T922 its excellent writing speed but also knocks secondary electrons out of the CRT faceplate mesh element thus causing the haze. From where we sit, the haze is a very small tradeoff for the writing speed. Never does it seriously obscure the traces.

During our dozens of hours of T922 use, we found the beam finder very advantageous when the screen "went blank" due to excessive manipulation of the trace position controls. That single pushbutton has saved many hours of pot twisting in search of a missing trace. We also like the trace brightness when examining some rather fast waveforms, and have found the T922 excellent for examining some of the fast waveforms on a disc-controller board. With our old scope, we had to darken the room just to get a glimpse of what was happening, but the T922 lets us work in normal room light. Even at the high brightness, the focus remains excellent. We also found the T922 capable of rock-steady sync at low-amplitude high frequencies.

The clearly identified controls have positive detents to permit easy setting. We also found that keeping the front-panel clean is a snap—all you need is a small sponge and warm water.

The relatively light weight of the T922 has allowed us to take the instrument into the field. It has withstood being bounced around in a van with no damage.

We find the T922 a well-balanced combination of accuracy, ruggedness, versatility, and human engineering. It is a bit more expensive than some of the "low-cost" dual tracers available, but the difference, in our opinion represents money well spent. Without a doubt, the instrument delivers value for its cost.

—*Leslie Solomon.*

CIRCLE NO. 104 ON FREE INFORMATION CARD

COMPUTER BITS

By Carl Warren

NCC Is Just Around The Corner

THOSE of you who live in the Chicago area will want to get ready to visit the National Computer Conference (NCC), to take place May 4–7 at McCormick Place. If you're unfamiliar with the show, it's the one where just about all computer companies in the industry get together to show their wares.

This year, the format of the show has been changed. Personal computers will no longer be separated; they will be part of the main exhibits.

Expect very heavy crowds and limited parking facilities. Those of you who may be coming from out of town will find that hotel space is at a premium, too, and you may have to stay quite a distance away if early hotel room reservations were not made.

Advance reports indicate that some of the real excitement at the show will be generated by the introduction of a number of personal computers from Japanese manufacturers. Expect to see units that are priced well under $500, and possibly a new offering from Apple.

Should your interest be in innovative disk systems, you can expect to find very-high-density floppies. For example, Iomega (Ogden, UT) is planning to show a 10M-byte floppy system. The unit employs a unique cartridge-type design and a flying head. No pricing yet for the end user, but expect something in the $3,000 range.

While there, you will want to make a stop at Vector Graphic's booth, where you will see the Models 3005 and 2600 desk-top computer systems. Both are unitized systems each consisting of a CRT, a keyboard, a four-slot S-100 bus backplane that houses a Z-80 microprocessor-based single-board computer, 64K RAM board, Flashwriter video board, and a dual-mode disk controller board. The basic differences in the systems are as follows. The 3005 comes with a Seagate Technology ST-506 Microwinchester and a Tandom quad density 5.25-in. floppy. The Model 2600, on the other hand, comes with two floppy drives.

A nice feature of the 2600 is that it can be easily upgraded to the 3005 by simply buying the Microwinchester. The controller will support it and three floppies. Its software is already optimized to support it. The Model 3005 is priced at $7,950; the 2600 at $4,995.

Vector Graphics has some really exciting software. Specifically, its Memorite III word processing package, with a 33,000-word spelling dictionary, is very useful. In concert with this type application software, they are offering "Execugraph," which is a Visicalc-like (from Personal Software) tabulating system.

When I asked Robert Harp, the company's chief executive officer, if they were going to be offering any of the software separately, he gave a qualified no. Harp asserts that they would lose too much control and wouldn't be able to offer the same level of support for the software as they do when it's with their systems.

Follow this visit by heading to Hewlett-Packard to view the new HP-83 system. Interestingly, the HP-83 is not really a new system; its actually a downgrade of the popular HP-85. The 83 offers all the features of the 85, including graphics, but is minus the built-in printer and tape cartridge drive.

HP officials said that they took this move since there was so much interest in the machine among computer hobbyists. However, a lower price was desirable and interest in the small printer and special tape cartridge system wasn't high. The HP-83 is priced at $2,250.

Think PM. One of the many things users of computer systems seem to forget is preventive maintenance (PM). This is basically just taking care of your system to avoid costly breakdowns.

In reality, PM is cleaning the CRT screen, dusting off the keyboard, and cleaning out paper dust from the printer.

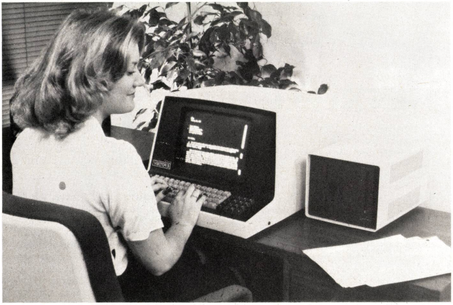
Although this sounds simple enough, it is often forgotten. To assist you in keeping your system up to snuff, Inmac, a computer supply house, is offering specialized maintenance kits for around $35 to $50, depending on contents.

Typically, what you can expect to find in the helpful kits are: a screwdriver and nutdriver set, CRT cleaning solution, font cleaning paper, and canned air for blowing out dust in hard-to-reach places. Some of the kits will contain small vacuums, and other specialized PM items.

To introduce these items, Inmac will be providing a free little kit at NCC just to get you started. Don't write for one—they won't send it! You must stop by their booth.

Make a MODEM Choice. One category of products that seems to hold high interest, among peripherals is the MODEM. Microperipheral Corp. in Redmond, WA. recently added some exciting products to their line in this field. This includes the TRS-80 Connection; the RS-232C Connection, for any system with an RS-232C port, the Atari Connection; and even support for some European systems. The Connection Modems start at $199.95 with an additional $79.95 for the autodial/autoanswer option. The MODEMs come complete with software, and you really only have to plug them in and compute.

(Continued overleaf)



Vector Graphic's 3005 word and data processing system has 5-MB 5¼-inch Winchester disk and one 630-KB floppy disk for expanded capability.

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Clean Your Dirty Head. To old Navy types, the lead-in to this paragraph may carry an interesting connotation, but for 3M it means keeping the heads on your floppy drives clean to avoid hard errors that may possibly ruin a valuable data diskette.

What 3M is offering is the Scotch brand 7400 and 7440 head-cleaning diskette kits. The 7400 is for 8-in. drives and the 7440 for 5.25-in. The $30 kits consist of two head-cleaning diskettes and one 4-oz bottle of cleaning solution with a dispenser cap. All you do is put the solution on the exposed cleaning surface, insert the diskette in the drive and access it. About 30 seconds later you have a clean, smooth head. Alan Henaman, 3M's marketing communication manager, says if you use the cleaning system at least once a week, you can probably avoid some unforeseen problems. I have to agree. Since I started using the cleaning diskettes, some error problems I was having literally disappeared.

Extend Your S-100 Bus. A few weeks ago, I was experiencing some interfacing problems with my S-100 bus system. I knew that I really needed to look at what types of signals were showing up on the serial card, but I couldn't reach the pins to hang a scope on them. Therefore, I called my old friend Bob Mullen of Mullen Computer Products. I explained my problem to Bob and he asked if I was a proud owner of an extender card. To which I replied yes, though only for the Heath H-8 bus. The next morning I had a TB-4 A/T extender board with logic probe. He sent the $79 assembled and tested version rather than the $59 kit since I wanted to solve my problem as quickly as possible. Within about 10 minutes of opening the package and inserting the board in the bus with the suspect board in it, I had isolated the problem. And I did it with the attached logic probe.

Shortly after solving this problem I got the urge to add a parallel port to the system. As luck would have it, I didn't have a handy piece of Vector Electronics S-100 bus wirewrap board. I was about to abandon my urge to build when I noticed that Bob had gone to all the trouble of providing a kluge area on the board just for such purposes, making the board a sort of universal tool.

I'm Dreaming of Some Software. The question that seems to show up the most in letters I receive from PE readers is "What software should I buy?" The question is really a difficult one to answer. It greatly depends on what you want or think you want to achieve, of course. However, basically I think you're safer to stick with well-known established companies. Since they have already gone to all the trouble to figure out what really is needed and works. There are lesser-known companies whose products may be super, of course, but risks are naturally higher in trying to choose the best ones.

Here are some software packages that I have used and consider good stuff. From Microsoft: BASIC interpreter, $350; BASIC Compiler, $395; COBOL-80, $750; FORTRAN-80, $500; MuMath, $250; MuLISP, $200 (the latter two packages offer engineers some marvelous possibilities, which I'll reserve for a later column); and EDit-80, $120.

All of the foregoing packages come under the heading of system software, and are used for developing other software. Microsoft has put a lot of effort in their design.

Give Jim a Call. Recently, I was talking to Jim Blake, Heath's software honcho. Jim was saying that things are going well for the "Softstuff" department of Heath. They have a number of packages, from CP/M to CBASIC, and some pretty good applications including a full-screen editor for the H-89 and H-19.

But Jim wasn't totally happy since he doesn't have all the software he would like. He wants things like a spooler, a tabulation program, business applications, and utility programs. Jim says he's interested in talking to competent programmers who can call him at (616) 982-3813.

While I was talking to Jim, I mentioned that I had just finished writing a book using Organic Software's Textwriter III ($125), which gave me the ability to automatically create a table of contents and an index. I thought Jim might want Mike Poshn, its creator, to make it available to Heath users—which is possible if you have CP/M.

I told Jim that Mike had developed two other packages; Datebook for $295, and Milestone for $395. These are applications that allow a user to set up an appointment calendar and develop Pert or goal charts.

Up Your Apple II to 64K. Dottie Hall, Microsoft Consumer Products' product manager, called recently to tell me that the 16K RAMCard for the Apple II was ready. This $195 add-on is designed to work in tandem with the Microsoft Softcard and

Hewlett-Packard's HP-83 personal computer.

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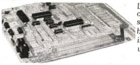
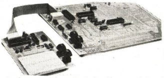


Level "A" is a complete operating system, perfect for beginners, hobbyists, industrial controller use. $129.95



Level "A" With Hex Keypad/Display.

LEVEL "A" SPECIFICATIONS

Explorer/85's Level "A" system features the advanced Intel 8085 cpu, an 8355 ROM with 2k deluxe monitor/operating system, and an advanced 8155 RAM I/O . . . all on a single motherboard with room for RAM/ROM/PROM/EPROM and S-100 expansion, plus generous prototyping space.

PC Board: Glass epoxy, plated through holes with solder mask. • **I/O:** Provisions for 25-pin (DB25) connector for terminal serial I/O, which can also support a paper tape reader . . . cassette tape recorder input and output . . . cassette tape control output . . . LED output indicator on SOD (serial output) line . . . printer interface (less drivers) . . . total of four 8-bit plus one 6-bit I/O ports. • **Crystal Frequency:** 6.144 MHz. • **Control Switches:** Reset and user (RST 7.5) interrupt . . . additional provisions for RST 5.5, 6.5 and TRAP interrupts onboard. • **Counter/Timer:** Programmable, 14-bit binary. • **System RAM:** 256 bytes located at F800, ideal for smaller systems and for use as an isolated stack area in expanded systems . . . RAM expandable to 64K via S-100 bus or 4k on motherboard.

System Monitor (Terminal Version): 2k bytes of deluxe system monitor ROM located at F000, leaving 0000 free for user RAM/ROM. Features include tape load with labeling . . . examine/change contents of memory . . . insert data . . . warm start . . . examine and change all registers . . . single step with register display at each break point, a debugging/training feature . . . go to execution address . . . move blocks of memory from one location to another . . . fill blocks of memory with a constant . . . display blocks of memory . . . automatic baud rate selection to 9600 baud . . . variable display line length control (1-255 characters/line) . . . channelized I/O monitor routine with 8-bit parallel output for high-speed printer . . . serial console in and console out channel so that monitor can communicate with I/O ports.

System Monitor (Hex Keypad/Display Version): Tape load with labeling . . . tape dump with labeling . . . examine/change contents of memory . . . insert data . . . warm start . . . examine and change all registers . . . single step with register display at each break point . . . go to execution address. Level "A" in this version makes a perfect controller for industrial applications, and is programmed using the Netronics Hex Keypad/Display. It is low cost, perfect for beginners.

HEX KEYPAD/DISPLAY SPECIFICATIONS

Calculator type keypad with 24 system-defined and 16 user-defined keys. Six digit calculator-type display, that displays full address plus data as well as register and status information.

LEVEL "B" SPECIFICATIONS

Level "B" provides the S-100 signals plus buffers/drivers to support up to six S-100 bus boards, and includes: address decoding for onboard 4k RAM expansion selectable in 4k blocks . . . address decoding for onboard 8k EPROM expansion selectable in 8k blocks . . . address and data bus drivers for onboard expansion . . . wait state generator (jumper selectable), to allow the use of slower memories . . . two separate 5 volt regulators.

LEVEL "C" SPECIFICATIONS

Level "C" expands Explorer/85's motherboard with a card cage, allowing you to plug up to six S-100 cards directly into the motherboard. Both cage and card are neatly contained inside Explorer's deluxe steel cabinet. Level "C" includes a sheet metal superstructure, a 5-card, gold plated S-100 extension PC board that plugs into the motherboard. Just add required number of S-100 connectors.

Explorer/85 With Level "C" Card Cage.

LEVEL "D" SPECIFICATIONS

Level "D" provides 4k of RAM, power supply regulation, filtering decoupling components and sockets to expand your Explorer/85 memory to 4k (plus the original 256 bytes located in the 8155A). The static RAM can be located anywhere from 0000 to EFFF in 4k blocks.

LEVEL "E" SPECIFICATIONS

Level "E" adds sockets for 8k of EPROM to use the popular Intel 2716 or the TI 2516. It includes all sockets, power supply regulator, heat sink, filtering and decoupling components. Sockets may also be used for 2k x 8 RAM IC's (allowing for up to 12k of onboard RAM).

DISK DRIVE SPECIFICATIONS

- 8″ CONTROL DATA CORP. professional drive.
- LSI controller.
- Write protect.
- Single or double density.
- Data capacity: 401,016 bytes (SD), 802,032 bytes (DD), unformatted.
- Access time: 25ms (one track).

DISK CONTROLLER/ I/O BOARD SPECIFICATIONS

- Controls up to four 8″ drives.
- 1771A LSI (SD) floppy disk controller.
- Onboard data separator (IBM compatible).
- 2 Serial I/O ports
- Autoboot to disk system when system reset.
- 2716 PROM socket included for use in custom applications.
- Onboard crystal controlled.
- Onboard I/O baud rate generators to 9600 baud.
- Double-sided PC board (glass epoxy.)

DISK DRIVE CABINET/POWER SUPPLY

- Deluxe steel cabinet with individual power supply for maximum reliability and stability.

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Beginner's Pak (Save $26.00!) — Buy Level "A" (Terminal Version) with Monitor Source Listing and AP-1 5-amp Power Supply: (regular price $199.95), now at SPECIAL PRICE: **$169.95** plus post. & insur.

Experimenter's Pak II (Save $53.40!) — Buy Level "A" (Hex Keypad/Display Version) with Hex Keypad/Display, Intel 8085 User Manual, Level "A" Hex Monitor Source Listing, and AP-1 5-amp Power Supply: (regular price $279.35), all at SPECIAL PRICE: **$219.95** plus post. & insur.

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greatly expands utility of the Apple II for running FORTRAN, COBOL, and BASIC-80. If you have this card and a 48K system you can boast a full 64K to your friends. Even if you're not quite ready for the card, give Dottie a call and ask for a catalog of some of the exciting products they have hidden away.

Come on, Charlie. If you are a Heath owner and want to keep in touch with other Heath owners, or are interested in finding out what Heath and others are making available, you should subscribe to BUSS—The independent Newsletter of Heath Company Computers. This informative monthly newsletter is full of ideas, gripes and helpful hints. Its editor, Charles Floto, says that interest is mounting in the Heath sysems; and, as a consequence, he is finding more to write about.

Charlie isn't pulling any punches either. When he thinks the Benton Harbor company hasn't done right, he calls it to their and your attention.

BUSS is $18 for 12 issues and worth the money. If you talk to anyone who is a member of a Heath users group, you'll more than likely find they keep a notebook of BUSS as a ready reference.

MORE INFORMATION

For additional information about products or services mentioned in this column, contact the companies directly.

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Vector Graphic Inc.
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213-991-2302

Answers to Questions. Since I get an unbelievable amount of a mail each month, I can't always answer each letter directly. So here are some short answers with questions implied.

No, Atari BASIC is not a Microsoft version. The reason that BASIC from the same software house, for the same processor, but for different systems, can look so different, is that the company making the system tells the software house what extensions they want and how they want them to work. Yes, you can do bit manipulation in BASIC, but you have to know what bit to toggle, and how logic AND, OR, and XOR operate. ◇

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COMPUTER SOURCES

By Leslie Solomon
Senior Technical Editor

Hardware

Atari RAM. The RAMCRAM can expand an Atari 400 system to 32K bytes and the Atari 800 to 48K bytes. In the 400, RAMCRAM replaces the Atari-supplied 8K module. This allows the 400 to use disks, printers, and other peripherals. Any 32K Atari 800 software will run on a 400 with RAMCRAM. Address: AXLON Inc., 170 N. Wolf Rd., Sunnyvale, CA 94086.

132 by 30 Terminals. The Displaymaster is a Z80-based terminal using a 13″ by 7″ P32 green phosphor CRT. It features 132 or 80 characters per line, 24, 27, or 30, lines, 16 programmable keys, numeric keypad, screen highlighting, addressable cursor, set-up mode, 129 ASCII characters, up to 19.2K-baud rate, Hazeltine/Lear-Siegler/DEC VT100 emulation, fixed tabs, 16K-byte display memory, auxiliary port, block mode, and line drawing. Options include separate keyboard, second 128-character set, 32K memory, graphics, and light pen. Address: GDS Inc., 1911 22nd Ave. South, Seattle, WA 98144 (Tel: 206-322-9330).

Hardware Catalog. Contains data on 6502 machines, power supplies, various Apple plug-ins, 2716 programmers, Z80 machines, A/D converters, and a number of bare boards. Address: John Bell Engineering, Box 338, Redwood City, CA 94064.

16-Bit Trainer. The TM990/189 University Module 16-bit trainer features a TMS9980A processor (16-bit), an on-board 45-key alphanumeric keyboard and 10-character display, a firmware debug monitor and symbolic assembler, a cassette interface, on-board user-addressable LEDs/speaker/displays, 16-bit programmable I/O controller with interrupts and timer, 4K bytes of ROM with 2K-byte expansion socket, 1K RAM, and optional EIA/20-mA interface. $299. The Memory and I/O Expansion Module expands the University Module by 8K, has sockets for 8K bytes of RAM, and 8K bytes of EPROM. It also includes an EPROM programmer for 2708/2716. $299. The TM990/519 Power Supply provides all necessary voltages for University Module. $65. Address: George Goode & Associates, Inc., 12840 Hillcrest Rd., Suite 113, Dallas, TX 75230 (Tel: 214-980-0730).

TRS-80 Add Ons. The AN-538 Analog Port Interface provides A/D and D/A conversion for the TRS-80. The unit also houses an interface with both latched 8-bit data output and 8 decoded device control lines. $79.95. The AN-511 Digital Port Interface provides 8 bits of input data, 8 bits of output data, 8 device control lines (decoded port addresses), and the 8-bit data bus at the front panel. $79.95. The AN-551 EPROM Programmer can program either 2716 or 2732 EPROMS from a BASIC program in less than 300 seconds. $89.95. The Digital Speech Processor provides voice interface for the TRS-80. Digitized voice data is saved in RAM or on diskette to create vocabulary files. $89.95. Address: The Design Solution Facility, Box 1225, Fayetteville, AR 72701 (Tel: 501-521-0281).

64K Apple. The RAMcard provides an additional 16K bytes of RAM to an Apple, making a 48K system (present maximum) into a full 64K system. With the Softcard, a full 56K CP/M environment is provided. $195. Address: Microsoft Consumer Products, 400 108th Ave., NE, Suite 200, Bellvue, WA 98004 (Tel: 206-454-1315).

SS-50 Interface. The ACIA Interface Card occupies one slot in the SS-50 system to allow users to design and prototype RS-232, 20-mA, or TTL outputs from two 6850 ACIAs. Separate baud rate control for each 6850 is provided. The card supplies +5 volts to chips and

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user area, and the IRQ line is jumper programmable for one or both 6850 IRQ outputs. $8.50 for bare pc board and instructions. Address: Quality Research Co., Box 7207, Spokane, WA 99207.

Software

List Management The Ultimail Version 5 List Management System for the TRS-80 Model I with 48K requires two mini-disks or one 8" floppy. It uses random disk files and stores 650 records on a mini or 1000 on the 8" diskette. Program routines include: data entry, database-record display, edit, delete, directory in alphabetic order, labels with zip code, and any number of labels printed per address. Each record consists of a zip code, alpha key entry for directory printouts, and 3 to 4 lines per address with the first up to 31 characters, second and third lines 29 characters, and fourth line 28 characters. Errors can be immediately corrected. $124.95. Address: Computer Generated Data, 5541 Parliament Drive, Suite 208, Virginia Beach, VA 23462 (Tel: 804-497-1165).

Apple PASCAL. The PASCAL Utility Express Package contains four procedural units that simplify I/O formatting: access and/or change in the disk directory from a PASCAL program: perform integer, string, and real conversions: and support files of variable-length records. It also contains five sample programs of PASCAL demos with BASIC equivalents, a routine to view disk files in ASCII or hex, a text formatter for simple word processing, and a program to maintain a variable-length data file for the international traveler. $45 on diskette. Address: Software Express, Box 50453, Palo Alto, CA 94303 (Tel: 415-856-9244).

Typing Tutor. Type-It is a typing tutor, a drill master, and a speed tester. It assumes the user knows nothing about typing, and is self paced. Runs on TRS-80 Model I, Level 2 or disk BASIC. Supplied on cassette or disk. $14.95. Address: Bluebird's Inc., 2267 23rd St., Wyandotte, MI 48192 (Tel: 313-285-4455).

New VisiCalc. The VisiCalc program, previously only available for the Apple, is now available for the Atari 800 and Commodore systems. The Commodore version automatically senses whether it is running in a PET with a 40-character screen, or the CBM 8032 with an 80-character screen. The VisiCalc creates a 64-column wide, 254-row high matrix on screen. It speeds repetitious calculations like inventory planning, sales forecasts, financial analyses, and modelling of physical phenomena. Address: Personal Software Inc., 1330 Bordeaux Drive, Sunnyvale, CA 94086 (Tel: 408-745-7841).

Payroll Package. The Payroll System calculates complete payroll transactions including Federal tax returns for 300 employees. It permits up to four user-definable pay rates for each employee, and handles tips, bonuses, expense reimbursements, advances, sick pay, and vacation pay. It will calculate for any combination of pay schedules: weekly, bi-weekly, monthly or semi-monthly. Three additional categories may be created for each employee. It will operate stand alone, or with the SSG General Ledger. Requires CP/M with 54K RAM, two disk drives, 132 column printer, 24 × 80 terminal, and 2.04 version of CBASIC. Address: Structured Systems Group, 5204 Claremont Ave., Oakland, CA 94618 (Tel: 415-547-1567).

PL/65 for AIM-65. The high-level system implementation language PL/65 is now available for the Rockwell AIM-65 computer. Control statements such as conditional execution (IF-THEN-ELSE) and conditional looping (FOR-TO-BY), coupled with simplified block capability, support structured program design techniques. It generates R6500 assembly language source code and allows assembly language instructions to

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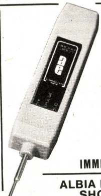

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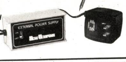

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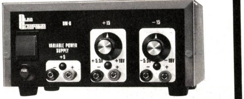

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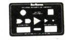

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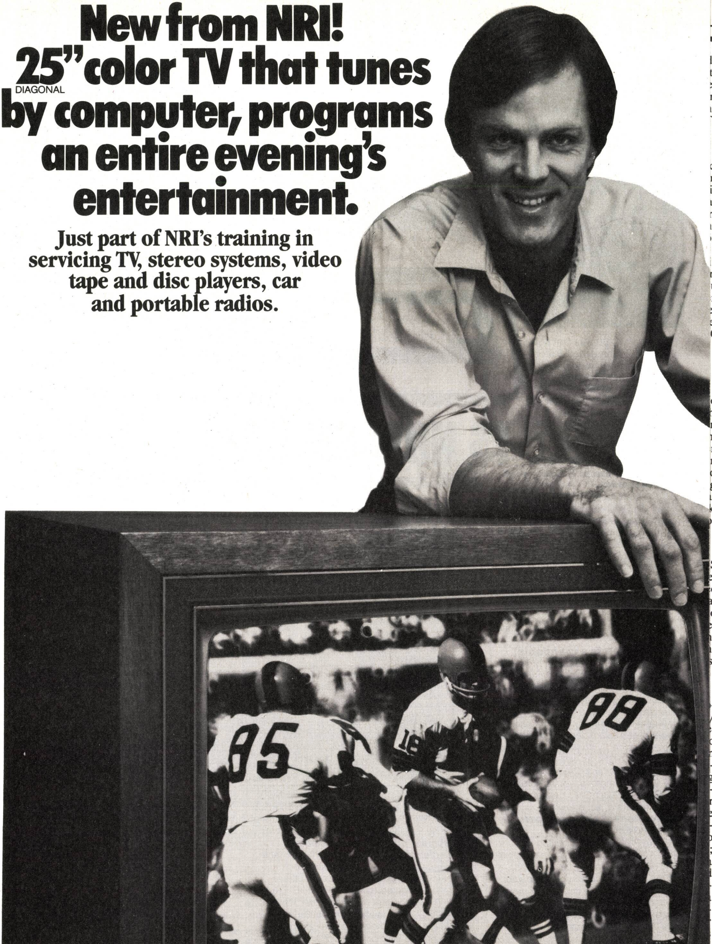

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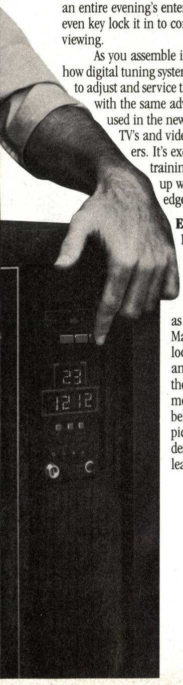

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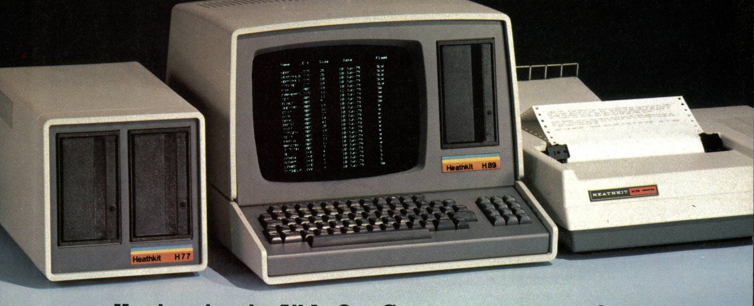

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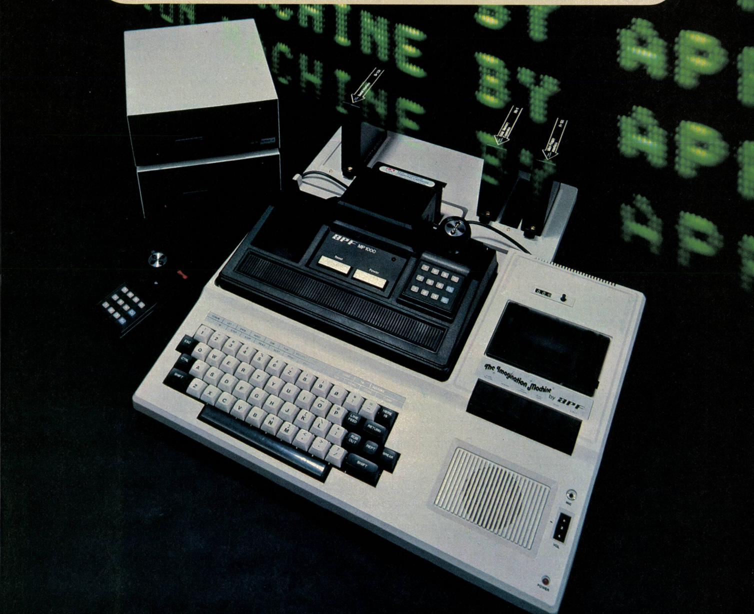
CIRCLE NO. 24 ON FREE INFORMATION CARD

PE Tests APF's "Imagination Machine"

IN THE "Imagination Machine" APF has a color-and-sound home computer with a strong video-games flavor. Built around an MC-6800 CPU, the basic system consists of two major parts: a stand-alone video-games-playing unit (MP1000) with handheld controllers that connects to a standard color or B&W TV receiver and uses ROM cartridges, and an interconnected base unit (MPA-10) with built-in cassette deck and keyboard that provides the "computer" portion of the system. Also supplied is a 12-kilobyte BASIC Interpreter cartridge that allows you to get the system up and running. In combination, the MP1000 nestles atop the MPA-10.

APF originally offered the MP1000 and MPA-10 separately for $129.95 and $499, respectively, or $599 when purchased together. Now the company is marketing the two units together as the Model 1 for only $399.

A number of options is available for expanding the Imagination Machine's computing abilities. Building Block 1 (BB1) at $199.95 enables you to add a Model TM-150 telephone modem or a hard-copy printer (not yet available). More memory than is provided by the 14K of ROM and 9K of RAM is available with the 8K memory module (R8K for $99.95). Building Block 2 (BB2) is a $149.95 floppy-disk controller for adding the Model D-100



5¼″ floppy disk drive ($399.95).

Software for the Imagination Machine is available in ROM cartridges and on cassette tapes. Like the BASIC interpreter, which comes with MP1000/MPA-10 system, most video games are stored in ROM cartridges; other programs (home finance, educational, etc.) are on tape. Prices for the software range from $19.95 to $29.95, with a "BASIC Tutor" on cassette at $49.95.

General Description. The MP1000 (Fig. 1) comes with its own power supply, two joystick/keypad controllers, circuitry to produce eight colors (green, yellow, blue, red, black, cyan, purple, and orange), and a sound generator. It also contains 2K of ROM, 1K of screen-display RAM, a peripheral interface adapter, and the MC6800 microprocessor. The MP1000 memory maps the display screen, which resides at memory locations 512 through 1023. A single ROM-cartridge slot is provided for plugging in any of the various games cartridges.

Connection of the MP1000 to a color-TV receiver is made through a supplied COMPUTER/TV isolation switch. After applying power, the TV selector should be set for channel 3, the switch on the isolation block to COMPUTER, and you're all set to go. Pushing RESET on the MP1000 brings up a Rocket Patrol game, which is built into every system.

The MP1000 can generate both alphanumeric characters and semigraphics, both a function of the internal ROM. A 5 x 7 dot matrix is used in generating the 64 ASCII characters, with one or two colors or in an inverse mode. The semigraphics mode is generated in an 8 x 12 box that is subdivided into four boxes, each four by six dots (Fig. 2). You can specify one of the eight available colors (dark green, yellow, blue, red, white, cyan, purple, or orange) for any given box and luminance on or luminance off to create specific effects.

Although the display is limited to 32 x 16 boxes per TV frame, the MP1000 can create "high-resolution" graphics with either 128 x 192 or 256 x 192 character dots. In this mode, the screen is mapped to 32 x 12 character boxes, each 8 or 4 dots wide by 16 dots high.

The joystick assemblies move the cursor up, down, left, and right on the TV screen. These are switch-type joysticks, rather than potentiometer types, which means that there are no intermediate points between left and right and top and bottom. The keypad is used for entering numbers (0 through 9), clearing the screen, and performing an implicit ENTER.

Using the optional games cartridges in the MP1000 is very simple. With the unit turned off, plug your choice of cartridge into the slot at the back of the player, power up, and press RESET. At this point, the menu of choices appears on-screen. Key in your choice and tell the computer how many players there will be.

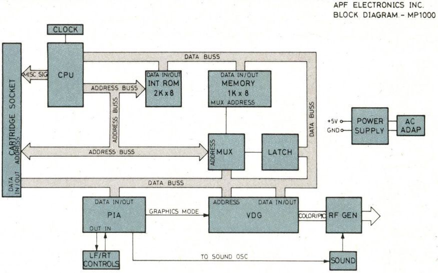


Fig. 1. Block Diagram of the MP1000. It contains 2K of ROM, 1K of screen-display RAM, and the MC 6800 microprocessor.

MP1000, via a J-shaped connector that also provides data and address buffering, brings computing capability. Basically, the MPA-10 permits programs on cassettes to be loaded into the computer and allows you to develop your own software and store it on tape. The MPA-10 also supplies the system's alphanumeric keyboard, a built-in cassette deck that operates under processor control, 8 kilobytes of RAM, and a 50-pin connector to accommodate optional peripherals. Interface with the TV receiver is still through the games-playing unit.

To connect the MPA-10, it is necessary to insert a grounding bar in the ROM cartridge slots. With this in place, the MP1000 sits in a dished-out area atop the MPA-10 and is electrically and mechanically secured by a special J-shaped connector. Then the 12-kilobyte BASIC Language Interpreter cartridge supplied with the MPA-10 plugs into a slot in the base unit.

Powering up both units and pressing ENTER causes the APF logo and "basic" (lower case, done in graphics) to be displayed in a rainbow of colors. To get into the BASIC command mode, the EN (enter) key on either joystick controller must be pressed, at which time, the computer clears the screen and places a block cursor in the upper left.

Programs can now be entered from the cassette deck or by typing them in from the keyboard. For tape operation, you must type in CLOAD or 1 CLOAD (depending on instructions supplied with the tape), followed by RETURN and RUN. A message then instructs you to rewind the tape, push PLAY on the cassette deck, and once again press RETURN. From here on, deck operation is under computer control, via the BASIC interpreter, until a prompt on the screen tells you to press STOP.

The MPA-10's keyboard is made up of 53 keys that generate only upper-case

Since it's set up in a manner similar to a standard Teletypewriter, such keys as HERE IS, BRK (break), and REPT (repeat) aren't used. Although an ESC (escape) key is provided and shown on the wiring matrix, it appears to be nonfunctional.

The keyboard setup includes 24 commonly used BASIC keyword commands that can be invoked with two simultaneous keystrokes. Above the keyboard are printed commands like CLOAD, PRINT, DIM, etc., that are invoked by holding down the CTRL (control) key and the key that corresponds to the desired command. This informs the computer of the command and spells out the command word on the screen.

Data transfer rate for the cassette system is approximately 1500 baud, which allows an 8-kilobyte tape to load in about 2 minutes. In addition, the tape system permits use of an audio track to create a voice header (via a microphone, not supplied) that can be heard from the deck's built-in speaker. Since tape system operation is under program control, data can be loaded and saved while a program is operating.

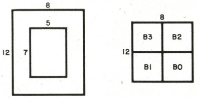
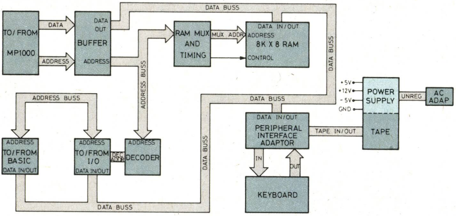


Fig. 2. Etiher alphanumeric characters (left) or semigraphics can be generated.

The BASIC interpreter permits access to the processor by a specific call and can handle BASIC statements in tandem with machine-language programs. To enter a machine-language routine from BASIC, you simply call location at 28672. Then, after entering your routine, typing G8894 tells the



APF ELECTRONICS INC.
BLOCK DIAGRAM - MPA10

Fig. 3. Block diagram of the MPA-10 base unit with built-in tape deck and keyboard. A plug connects to the MP1000.

BASIC at location 8894. At this point, you can write a BASIC program that calls the machine-language routine. One of the things you can do using machine-language routines is divide the screen into four quadrants and have activity occur in each. Incidentally, more than one machine-language routine can be written and called from BASIC as needed.

The built-in sound generator can add an extra dimension to your programs. Sound can be created using either machine-language routines or the POKE command in BASIC. Should you decide to add the optional floppy-disk system to your Imagination Machine (we didn't have it for this review), APF's Basic interpreter already contains the necessary disk operating system (DOS).

Evaluation. Taken as a whole, the basic MP1000/MPA-10 Imagination Machine performed as described in the well-written and comprehensive literature. (We didn't have the optional building blocks for this report.) Machine- and BASIC-language programs, including those that use graphics and color, were easy to load, run, and save on tape.

During our initial evaluation, however, a few annoying bugs showed up. One was erratic operation of the joystick/keypad controllers. Most of the key-sticking problem cleared up after several hours of exercise, but a multiple-entry problem persisted. When queried about this, APF informed us that our evaluation unit was part of an early production run and was fitted with older controllers. We've been assured that all Imagination Machines manufactured since last November have been fitted with newly designed controllers that have looser-fitting keys and full debouncing.

Another minor annoyance we encountered was in cassette-deck operation. We found that, even when a program tape was fully rewound, we still had to run the rewind sequence before it would load.

Most of the games cartridges we tried were apparently geared to the younger set. Only four games—Hangman, Tic-Tac-Toe, Breakdown, and Pinball—offered more than passing challenge.

Of the taped programs we reviewed, "Music Composer and Piano Player" and "Artist and Easel" were the best in terms of demonstrating what you can do with the computer's hardware and software. On the whole, however, the taped programs fell short of their potential for producing three-dimensional graphics, though they made good use of the computer's two-dimensional graphics, color, and sound-generating capabilities.

APF's BASIC interpreter is fairly good and comes with an easy-to-follow manual that spells out every step of its use in detail, but it does have limitations. For example, the BASIC doesn't provide such attributes as editing functions, renumbering, and automatic line numbering. Trig functions aren't provided, either, but they can be written as subroutines and called by a program as needed. Curiously, no "scratch" or "kill" command can be invoked to erase a BASIC program once it has been entered. If you wish to erase a program, you must either write a new program over it or press RESET on the MP1000 and the EN key on either controller. We suggest the latter, since it's a two-key operation and the BASIC in ROM is available immediately.

Comment. The ready-to-go Imagination Machine offers a fairly inexpensive entry to the world of microcomputing. This is especially true when considering its built-in features such as video color and sound generation, cassette deck, and hand controllers. It has a growing software support base and a nice list of optional accessories that will allow you to expand to a reasonably powerful computer system, though it is clearly not designed for serious business or professional use. As a low-priced home computer, sophisticated video games player and computer trainer, the Imagination Machine is difficult to beat.

—*Carl Warren*

CIRCLE NO. 103 ON FREE INFORMATION CARD

NEW!!! THE
ELECTRIC MOUTH *

ELF II VERSION

for S100, Elf II, Apple, TRS-80 Level II*

From $99.95 kit

Now — teach your computer to talk, dramatically increasing the interaction between you and your machine.

That's right: the ELECTRIC MOUTH actually lets your computer talk! Installed and on-line in just minutes, it's ready for spoken-language use in office, business, industrial and commercial applications, in games, special projects, R&D, education, security devices — there's no end to the ELECTRIC MOUTH's usefulness. Look at these features:

- ★ Supplied with 143 words/letters/phonemes/numbers, capable of producing hundreds of words and phrases.
- ★ Expandable on-board up to thousands of words and phrases (just add additional speech ROMs as they become available).
- ★ Four models, which plug directly into S100, Apple, Elf II and TRS-80 Level II computers.
- ★ Get it to talk by using either Basic or machine language (very easy to use, complete instructions with examples included).
- ★ Uses National Semiconductor's "Digitalker" system.
- ★ Includes on-board audio amplifier and speaker, with provisions for external speakers and amplifier.
- ★ Adds a new dimension and excitement to programming; lets you modify existing programs and games to add spoken announcements of results, warnings, etc.
- ★ Installs in just minutes.

Principle of Operation: The ELECTRIC MOUTH stores words in their digital equivalents in ROMs. When words, phrases, and phonemes are desired, they are simply called for by your program and then synthesized into speech. The ELECTRIC MOUTH system requires none of your valuable memory space except for a few addresses if used in memory mapped mode. In most cases, output ports (user selectable) are used.

Spoken Material Included

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Acct. No. ____________

Signature ____________ **Exp. Date** ________

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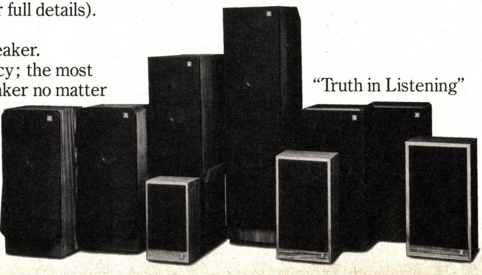


"Truth in Listening"

Popular Electronics
APRIL 1981

BY BERT MARLIN

OSCILLOSCOPES:
1981

A guide to medium-priced scopes for experimenters

Whatever your interest in electronics, sooner or later, you're going to need an oscilloscope. Having reached this point, you have a big decision to make. Based on your budget and needs, you'll have to choose from among literally dozens of different scopes, each with its own set of features and functions. There's no doubt that one or more will meet your needs, but be prepared to make a sizable investment—up to $2,000 or more if your needs are very critical and demanding. Choosing a scope

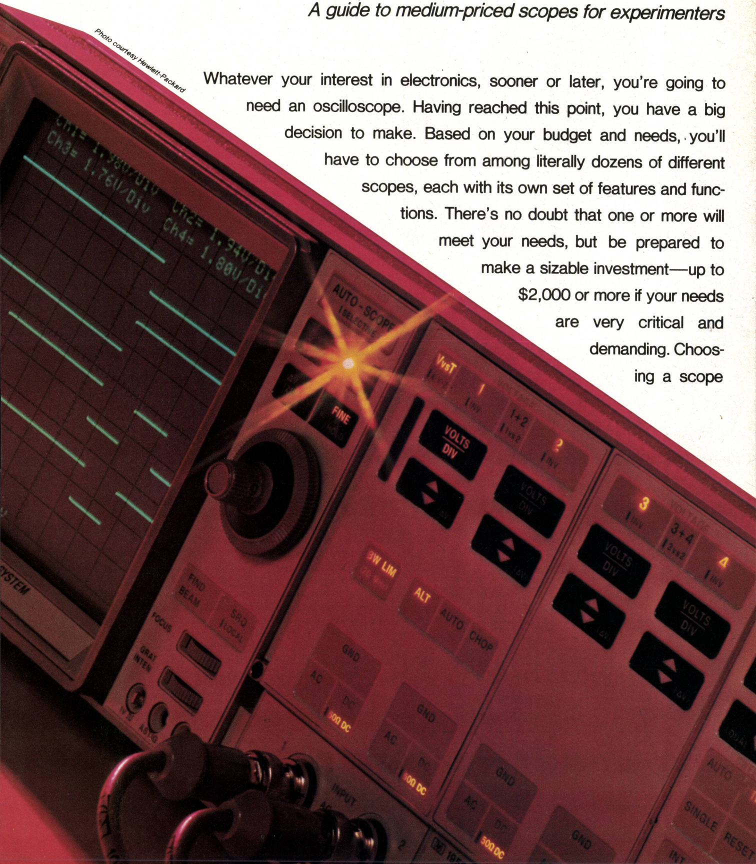


Photo courtesy Hewlett-Packard

demands considerably more comparison shopping than any other piece of general-purpose test equipment. If you take your time and learn what a scope can and should do, you'll be able to make an intelligent decision.

What Is An Oscilloscope? In general terms, an oscilloscope is an electronic "window" that allows you to see the variations of voltage at any point in a circuit. The scope will display in graphic form on its screen the actual waveform of voltage plotted against time. In addition, it can serve as an accurate ac/dc voltmeter and time-period counter.

To accomplish all its functions, the typical scope is made up of five major interrelated parts: vertical amplifier section, horizontal amplifier section, sweep and synchronization circuits, picture tube (cathode-ray tube or CRT), and power supply.

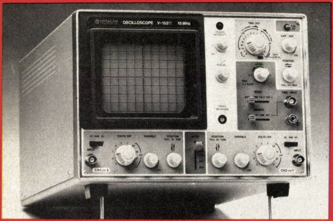
The vertical amplifier accepts the input signal and amplifies it to produce vertical deflection of the beam in the CRT. To be of value, the vertical amplifier's frequency response or bandwidth, must be wide enough to encompass both the fundamental frequency of the input signal and a minimum of 10 harmonics (whole multiples of the fundamental). Input-signal level to the vertical amplifier is controlled by a frequency-compensated step attenuator/vernier-control setup. Input impedance is usually at least 1 megohm bypassed by a low-picofarad capacitance to present minimum instrument loading of the circuit under test. The sweep and sync section includes the circuitry that makes the electron beam in the CRT move from left to right. Every time the beam traverses the screen, it produces a trace that can be deflected up and down by a signal from the vertical-amplifier section. When it reaches the right side of the screen, the beam is cut off. The horizontal deflection voltage quickly reverts to a value corresponding to the left edge of the screen. This prevents the right-to-left retrace from appearing on-screen.

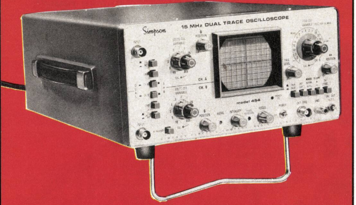
The horizontal-amplifier section usually serves two purposes. First, it amplifies the sweep signals for application to the CRT's horizontal deflection plates. In addition, it serves as a "second" signal-input amplifier when a scope is used as a vector display to compare phase relationships between two signals. In this mode, sweep is disabled. (Not all scopes are equipped for vector display. Any scope that is will have an "X-Y" legend at one position of its input selector.) The vector mode is useful for color-TV and stereo alignments. For X-Y use, bandwidth of the horizontal amplifier should be comparable to that of the vertical amplifier, and, more important, the phase response of the two amplifiers should match as closely as possible.

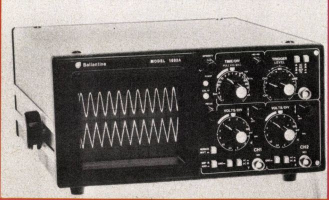
The CRT can be either round, usually 5″ in diameter, or rectangular. Rectangular tubes provide a full-screen display, including the corners, while the construction of the round tube cuts off the corners. The usual practice of applying several kilovolts to the final anode of the CRT suffices when the trace does not have to move too rapidly. However, to display a low-repetition-rate waveform with a fast rise time, the trace moves so fast that it may become too faint, even with the BRIGHTNESS fully up. "Post deflection acceleration" delivers a bright trace at almost any beam speed.

The power supply in a scope is of critical importance if you expect to perform precise tests and measurements. Since it supplies power to every part of the scope, the power supply must be tightly regulated to prevent undesired interactions between circuits. In a poorly regulated supply, for example, the amplitude of the displayed waveform might vary slightly if you adjust the intensity (brightness) control.

Features. More than any other factor, features are what "tailor" a given scope to your needs. "Standard" features vary tremendously from manufacturer to manufacturer and even


Hitachi Model V-152


Simpson Model 454


Ballantine Model 1032A

from model to model of a single manufacturer. Some features that are common to all scopes are: BNC-type input connectors; CRT intensity and astigmatism controls; trace-positioning controls; vertical and horizontal "gain" controls; sweep-speed selectors; etc. Features that might be shared by many, but not all, scopes include: dual-trace display capability; sweep magnification; triggered sweep; on-board calibrating voltage and/or frequency; and vector-display capability.

One of the major features of a scope is the type of sweep it uses. Recurrent sweep, found primarily in economy scopes, is generated by a free-running oscillator whose frequency is adjusted by sweep controls on the scope's front panel. The oscillator can be synchronized to the vertical input signal, ac power line, or an external source. If the sync isn't correct, the displayed waveform will drift across the screen. Triggered-sweep, on the other hand, starts only when an input (trigger) signal is applied to the vertical amplifier. With no signal present, no trace appears. The sweep is very linear and stable, and eliminates waveform shift.

Triggered-sweep ranges generally permit measurements on very slow and very fast waveforms. Sync can be taken from the vertical amplifier, power line, or an external source. Provisions are usually made to allow triggering on the positive- or negative-going side of the input signal, at almost any intermediate point on the waveform, or in conjunction with a built-in TV-like sync clipper (from a TV signal used as the vertical-input source).

Some scopes are equipped with a feature called "sweep magnification," which horizontally expands the sweep by a factor of 5 or 10, depending on design. The magnifier "stretches" the sweep as though it went beyond the edges of the CRT screen. Using the horizontal positioning control, you can move the elongated sweep back and forth past the "window" of the screen to obtain a magnified view of one-fifth or one-tenth of the waveform.

The importance of sweep magnification lies in its ability to let you examine the leading or trailing edge of a pulse at a faster sweep than would otherwise be possible. Keep in mind, however, that sweep magnification decreases the brightness of the trace.

While many modern scopes are still single-trace instruments, a growing number of models have dual-trace capability. The latter appear to display two traces simultaneously, but in actuality, the traces are drawn by a single electron beam, using either of two modes.

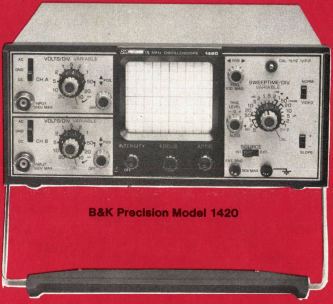
In the "alternate" mode, each channel's waveform is displayed for 50% of the time, with the channels alternating with successive sweeps. At very low sweep speeds, the traces would be seen at different times, but at higher speeds, persistence of vision (and the CRT phosphor) makes both traces appear to be on-screen simultaneously.

In the "chop" mode, an internal oscillator gates the two channels on and off at a very high rate, breaking the two traces into series of minute "slices" that appear to make up two continuous waveform traces. One problem with the chop mode is that the input signal frequency may be very close to the chop frequency, which would cause the displayed image to be blurred. Some scopes permit adjustment of the chop frequency to get around this problem. If the chop frequency cannot be adjusted, you can simply switch to the alternate mode. The advantage of dual-trace display is that you can compare two signals for coincidence, measure the time delay between them, or compare the output of a circuit with its input.

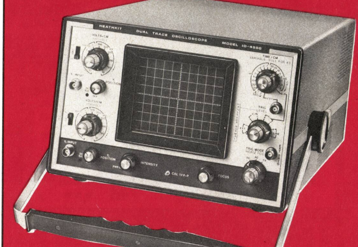
Intensity modulation is another feature that many scopes provide as standard fare. A "Z-axis" input, usually located on the rear of the scope, allows modulation of trace intensity by the signal applied.

A feature that until very recently could be found only on laboratory-grade scopes priced in the $5,000 range and now

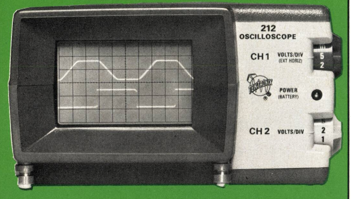
Phillips Model PM3207



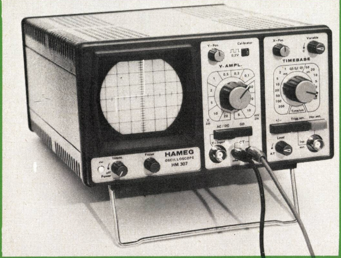
B&K Precision Model 1420



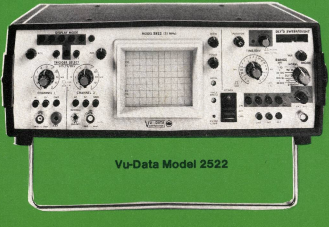
Heathkit Model IO-4550



Tektronix Model 212



Hameg Model HM 307



Vu-Data Model 2522

appearing on a few scopes that list for less than $2,000 is delayed, or intensified, sweep. It is a very sophisticated form of sweep magnification, that allows you to examine any portion of the trace at any speed up to the main sweep speed. With delayed sweep, you can take a 1% slice from any point on the trace, and expand it to fill the entire screen, without losing brightness.

Options. A very practical way of extending the usefulness of a basic scope is by supplementing the instrument with options. Wise selection of options, can often make a marginal scope operate beyond its normal capabilities.

Among the most popular options are specialty probes. Voltage-divider probes that have a 10:1 ratio can extend the vertical-input limit by a factor of 10. There are also probes that can convert a 50-kV signal to a level that is safe for a normal scope input. And high-frequency demodulator probes allow you to observe amplitude modulation impressed on a carrier of up to 250 MHz. Most of these probes provide a high degree of isolation between the scope and circuit under test and are designed to minimize loading.

Another very useful accessory for work on digital circuitry, is a multichannel adapter. If you have a single-trace scope and want dual-trace capability, you can buy a two-trace adapter. For computer work, however, you'll almost certainly want an eight-trace adapter. Adapters connect directly to the vertical input of the scope and require separate probes for each "channel." Additionally, trace-positioning controls are provided on the adapters themselves.

A scope represents a sizable investment and should receive tender loving care if you want to enjoy its full lifespan. If you plan to set your scope in a fixed location, seriously consider buying a cover to protect it from dust and other foreign matter. A scope that must be transported from one location to another should have a protective carrying case.

Now beginning to appear on lower priced scopes is "trigger view," which allows observation of the trigger signal, in addition to the vertical input signals. At least one scope that lists for less than $2,000 comes with a combination of delayed sweep and trigger view so you can look at the entire main sweep, delayed sweep, main trigger, and delayed trigger on four traces simultaneously! Trigger view is an internal connection that adds the trigger to the display. Its bandwidth is limited, and gain is fixed and uncalibrated. Consequently, trigger view is useful for providing a reference timing marker, rather than for critical observation of the trigger.

In the past, calling a scope "portable" simply meant that it had a handle. The modern portable scope, however, is a truly portable instrument. It is compact, lightweight, battery powered, and provides a full range of features and functions.

Specifications. You can tell a great deal about how a scope will perform by closely examining the manufacturer's literature, especially the list of technical specifications. Since oscilloscopes are "professional" instruments, their published specifications are, on the whole, comprehensive.

Bandwidth is the most often quoted spec. This frequency-response parameter is almost universally specified as the frequency at which the displayed vertical signal drops to half the amplitude (−3-dB point) it was at some arbitrarily selected low frequency. While most scopes will respond beyond the stated −3-dB point, higher-frequency signals will be displayed at progressively lower amplitude than signals of the same level within the rated bandwidth.

Scopes that use peaking networks to extend their upper-frequency response can attain a bandwidth of 10 or 15 MHz, beyond which, response drops off precipitously. Hence, a fast-rising high-frequency pulse may cause "ringing" in the viewed waveform. Some scopes, particularly those designed

Manufacturer and Model	Cost ($)	Channels	Bandwidth (MHz)	Maximum Input Sensitivity (mV/div)	Minimum Input Sensitivity (V/div)	Fastest Calibrated Sweep Speed (μs/div)	Slowest Calibrated Sweep Speed (s/div)	Sweep Magnifier	Dimensions in.	Remarks
B&K Precision										
1420	825	2	15	10	20	1	0.5	5	3.3 x 7.8 x 10	Battery-powered
1432	855	2	15	2	10	0.5	0.5	5	5.5 x 8.3 x 14.3	Battery-powered
1405	289	1	5	10	—	—	—	—	6 x 7.5 x 12	Recurrent sweep. Max. sweep speed 100 kHz; min. 10 Hz
1466	560	1	10	10	20	1	0.5	5	7.4 x 10.1 x 14.8	
1476	715	2	10	10	20	1	0.5	5	7.4 x 10.1 x 14.8	
1477	840	2	15	10	20	0.5	0.5	5	7.4 x 10.1 x 14.8	
1520	840	2	20	5	20	0.5	0.5	10	7.4 x 10.1 x 13.9	
Ballantine										
1021	765	1	12	5	2	1	0.1	10	3.3 x 8 x 8.7	Battery-powered
1022	895	2	12	5	2	1	0.1	10	3.3 x 10 x 11.8	Battery-powered
1031A	765	1	25	5	20	1	0.5	10	5.3 x 11.5 x 15.5	
1032A	945	2	25	5	20	1	0.5	10	5.3 x 11.5 x 15.5	
Gould										
OS255	795	2	15	2	10	0.5	2	5	5.5 x 12 x 18.3	
Hameg										
HM 307	405	1	10	5	20	0.5	0.2	No	4.5 x 8.4 x 10.4	Has built-in component test circuit
HM312	609	2	20	5	20	0.5	0.2	5	9.3 x 8.4 x 15	
HM412	913	2	20	5	20	0.5	0.2	5	9.3 x 8.4 x 15	Delayed sweep
Heath										
SO-4105	375	1	5	10	20	0.2	0.2	No	8 x 13 x 17	Available in kit as IO-4105 for $200
SO-4205	450	2	5	10	20	0.2	0.2	No	8 x 13 x 17	Available in kit as IO-4205 for $280
IO-4235	950	2	35	2	10	0.05	0.2	5	7.8 x 13.8 x 19.8	Delayed sweep. Available wired as SO-4235 for $1295
SO-4510	840	2	15	1	5	0.1	0.2	No	6.5 x 12.9 x 19.3	Available in kit as IO-4510 for $590
SO-4550	650	2	10	10	20	0.2	0.2	5	6.5 x 12.9 x 19.3	Available in kit as IO-4550 for $400
IO-4555	290	1	10	10	20	0.2	0.2	No	6.9 x 12.9 x 19.3	Kit form only
Hewlett-Packard										
1220A	795	2	15	2	10	0.01	0.5	No	7.1 x 12.3 x 16.3	
1222A	895	2	15	2	10	0.01	0.5	No	7.1 x 12.3 x 16.3	
Hitachi										
V-059B	1200	1	7	50	2	10	20	10	3.4 x 7.8 x 11.5	Battery-powered
V-151	545	1	15	5	5	0.2	0.2	10	7.5 x 10.8 x 15.8	
V-152	695	2	15	5	5	0.2	0.2	10	7.5 x 10.8 x 15.8	
V-301	745	1	30	5	5	0.2	0.2	10	7.5 x 10.8 x 15.8	
V-302	945	2	30	5	5	0.2	0.2	10	7.5 x 10.8 x 15.8	
Kikusui										
5509	475	1	10	10	5	1	0.1	5	8.3 x 9.8 x 16.5	
5513	595	2	10	10	5	1	0.1	5	8.3 x 9.8 x 17.1	
5520	795	2	20	5	5	0.2	0.5	5	8.3 x 9.8 x 17.1	
Leader Instruments										
LBO302	790	2	10	10	5	1	0.2	5	4.8 x 7.8 x 11.8	
LBO308S	975	2	20	2	10	0.5	0.2	5	4.6 x 9.2 x 12.6	
LBO310A	290	1	4	20	—	—	—	—	7.5 x 5 x 12	Recurrent sweep. Max sweep speed 100 kHz; min 10 Hz
LBO507A	625	1	20	10	20	0.5	0.2	5	6.8 x 10.3 x 14.8	
LBO508A	880	2	20	10	20	0.5	0.2	5	6.8 x 10.3 x 14.8	
LBO511	420	1	10	300	—	—	—	—	7.1 x 9.8 x 16.3	Recurrent sweep. Max. sweep speed 100 kHz; min. 10 Hz
LBO513	535	1	10	5	10	0.5	0.2	5	6.8 x 10.3 x 14.8	
LBO514	695	2	10	5	10	0.5	0.2	5	6.8 x 10.3 x 14.8	
Lectrotech										
TO-55	475	1	10	10	20	0.5	0.2	5	9 x 10 x 13	
TO-60	575	2	15	100	20	0.5	0.2	5	9 x 10 x 13	
Non-Linear Systems										
MS-15	350	1	15	10	50	0.1	0.5	5	2.7 x 6.4 x 8	Battery-powered
MS-215	465	2	15	10	50	0.1	0.5	No	2.9 x 6.4 x 8	Battery-powered
MS-230	598	2	30	10	50	0.1	0.5	No	2.9 x 6.4 x 8	Battery-powered
Philips										
PM3207	795	2	15	5	10	0.5	0.2	5	5 x 11.8 x 14.6	
PM3225	675	1	15	2	10	0.5	0.2	5	Not specified	
PM3226	975	2	15	2	10	0.5	0.2	5	Not specified	
Simpson										
452	830	2	15	5	10	0.2	0.5	5	6.5 x 12 x 16	
454	675	2	15	5	10	0.5	0.5	No	4.6 x 9.8 x 13.3	
Soltec										
5101B	495	1	10	10	5	0.1	0.1	5	5.8 x 6.2 x 6.2	
5102B	640	2	10	10	5	0.1	0.1	5	5.8 x 6.2 x 6.2	
Tektronix										
212	1350	2	0.5	10	5	5	0.5	5	3 x 5.3 x 9.5	Battery-powered
213	1750	1	1	20	100	2	0.5	5	3 x 5.2 x 9	Battery-powered
221	1325	1	5	5	100	1	0.2	10	3 x 5.2 x 9	Battery-powered
Viz										
WO-527A	575	1	15	10	20	0.5	0.5	10	7.5 x 13.5 x 17.5	
WO-555	799	2	15	10	20	0.5	0.5	10	7.5 x 13.5 x 17.5	
Vu-Data										
PS915A	1120	1	20	10	20	0.1	10	5	2.5 x 8.5 x 15.4	Battery-powered
PS935	1695	2	35	5	10	0.1	0.5	10	4.2 x 8.5 x 15.4	Battery-powered
PS950	1999	2	50	5	10	0.1	0.5	10	4.2 x 8.5 x 15.4	Battery-powered
2521	1395	2	25	5	10	0.1	0.5	5	5.8 x 12.5 x 11.5	Battery-powered
2522	1795	2	25	5	10	0.1	0.5	5	5.8 x 12.5 x 11.5	Delayed sweep

MANUFACTURERS' ADDRESSES

B&K Precision
6460 West Cortland St.
Chicago, IL 60635

Ballantine Laboratories
P.O. Box 97
Boonton, NJ 07005

Gould Inc.
Instruments Division
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Cleveland, OH 44114

Hameg
191 Main St.
Port Washington, NY 11050

Heath Company
Benton Harbor, MI 49022

Hewlett-Packard
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Palo Alto, CA 94304

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Woodbury, NY 11797

Kikusui
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Leader Instruments
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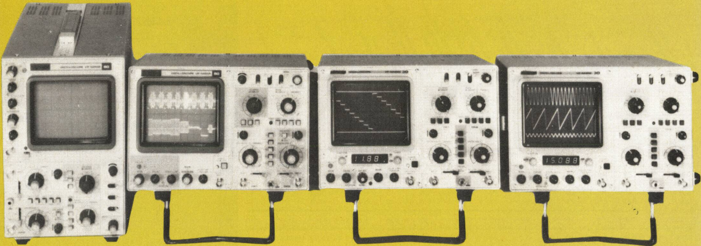


Soltec Series 500

for pulse waveform viewing, have upper-frequency limits (−3-dB point) of only 5 MHz or so, followed by a gradual rolloff. Such a scope can often display very-high-frequency waveforms with less distortion than one with double the rated bandwidth and a fast upper-end rolloff. But remember to display a reasonable representation of a pulse waveform, a scope must pass at least 10 harmonics of the fundamental scope's vertical amplifier frequency.

Sweep speed is closely related to bandwidth. It is the speed at which the CRT beam scans horizontally across the screen and is specified in terms of time per division, a division being one of the major segments along the horizontal axis of the graticule. (The graticule divides the CRT screen into squares, usually 10 boxes horizontally by eight vertically. Box rulings are usually 1 cm apart but can be anywhere between 0.5 and 0.9 cm apart on scopes with smaller CRTs. A few very expensive laboratory scopes have rulings more than 1 cm apart.)

In general, the fastest sweep speed ranges from 50 nanoseconds per division to 5 microseconds/division. Slowest speed is normally 0.2 or 0.5 second/division. Speed is usually switch-selectable in a 1-2-5 sequence. You'll have to worry about the sweep speed only if you must measure periods of repetitive waveforms.

The time at which the sweep begins can be every bit as important as how fast it is. Internal sweep triggering makes it difficult to see the leading edge of the input signal because the sweep begins slightly after the input waveform. A few scopes come with a delay line connected in series with each input jack to delay the signal for a short period of time so that the sweep can begin before the signal is displayed. This allows you to see the leading edge of the waveform. Another important parameter is how large an input signal is required for stable triggering. Check this specification if you expect to be working with low-level signals.

Sensitivity refers to the level of input voltage that produces one division of *vertical* scan on the CRT. Sensitivity is usually switch selectable in a 1-2-5 sequence. Maximum sensitivity ranges between 2 and 5 mV/div and minimum up to 100 V/div. Those scopes that have a built-in feature that trades off bandwidth for sensitivity are calibrated in terms of sensitivity at full bandwidth for all but the most sensitive range, which is calibrated at the reduced bandwidth.

In many applications, the sensitivity that counts most is the smallest voltage that produces one full division of deflection. Some scopes are equipped with the vertical equivalent of a sweep magnifier, called a vertical multiplier, which allows expansion of the vertical scan by a factor of five. Using the vertical multiplier, however, can reduce bandwidth.

There are some applications for which minimum sensitivity can be just as important. Minimum sensitivity is the maximum input voltage the scope can handle while calibrated and still produce just one division of scan. Since most scopes have graticules eight divisions high, the maximum peak-to-peak voltage a scope can display and remain calibrated is eight times the greatest V/div setting provided. A scope whose minimum input sensitivity is 5 V/div, for example, can accurately display a signal of no more than 40 V peak-to-peak. A scope with a 100 V/div sensitivity, on the other hand, can accurately display a signal 20 times larger.

Choosing a Scope. Concentrate on those scopes that will fill your needs through the projected lifetime of the instrument. Stay within your budget, but buy what you really need. On the other hand, every "extra" you buy—more bandwidth, greater sensitivity, sweep magnifier, vector-display capability, etc.—is going to add to the cost. For example, if you're primarily interested in analyzing audio amplifiers, there's little point in paying for a 50-MHz scope when a much less expensive 5-MHz model will do. Conversely, for digital work, you may find that nothing less than a 10-MHz instrument will do the job.

Depending on what's available in your budget range, you may have to make some tradeoffs. You may find, for example, a scope that has the bandwidth you need but insufficient sensitivity; and those that offer both are priced beyond your means. In a case like this, you might compromise a bit on bandwidth to obtain the required sensitivity. Should you find a scope in your price range that gives everything you need except a second channel, you can buy it and add a two-channel adapter when your funds permit.

When comparison shopping, don't forget to look at the list of options available. As pointed out above, some of these can give a basic scope capabilities normally reserved for a more expensive instrument. Whatever choice you make, if you've done your homework well, a scope will give you a new vantage point on electronic circuits. ◇

POWER SUPPLIES FOR OP AMPS

BY ARTHUR F. BLOCK

For best performance from operational amplifiers, special power-supply needs should be satisfied

OPERATIONAL-amplifier circuits almost always call for power sources that furnish clean, stable dc. Batteries are sources of good dc, but their expense relegates them principally to portable applications where commercial ac power is not readily available. The more economical solution to the problem of powering op amps is to use a *power supply* to convert commercial ac into smooth dc. In this article, we will examine several basic power-supply circuits that are well suited for use with operational amplifiers.

Symmetry is one of the principal characteristics required of most op-amp power supplies. Integrated operational amplifiers usually have two power-supply terminals—V+ and V−. If the voltages applied to these terminals are not symmetrical with respect to the input signal's ground potential (be it earth ground or an "artificial" ground), the output signal will ride on a dc level proportional to the power-supply asymmetry. This is usually undesirable—if a dc voltage is to be amplified, there will be error; if an ac voltage is to be amplified, capacitive coupling might be needed to prevent the upsetting of a subsequent stage's bias levels. Also, the possibility exists that the output signal will be asymmetrically clipped.

There are two basic types of power supplies that can be used with operational amplifiers—*bipolar* and *single-ended*. In a bipolar supply, positive and negative output voltages (usually equal in absolute value) are generated. The required symmetry arises from the fact that both the positive and negative supply rails are removed from ground by equal but opposite voltages. A single-ended supply generates only one voltage referenced to ground—either positive or negative. The ground of the power supply functions as one of the supply rails, and an "artificial ground" or "signal ground" is synthesized with a resistive voltage divider for reference purposes. This provides the required symmetry to the circuit.

Each type of supply has advantages and disadvantages. A bipolar supply furnishes a signal ground that is at true ground potential. This simplifies circuit design and eliminates at many points the need for capacitive coupling. However, a bipolar supply is more complex than a single-ended one and is more expensive to construct. A single-ended supply is simpler but usually makes the circuit to be powered slightly more complex. Let's examine some basic supplies of each type and see how they can be used to power op-amp circuits.

Basic Power Supplies. Appearing in Fig. 1 are simple single-ended (A) and bipolar (B) power supplies. In the single-ended supply, bridge rectifier *D1* through *D4* delivers pulsating dc to filter capacitor *C1*, which provides a smoothed dc output. Resistor *R1* is a bleeder component. A voltage divider comprising *R2* and *R3* synthesizes an artificial signal ground at half of the positive dc output voltage (assuming *R2* = *R3*) or approximately +17 volts. The op amp's positive power-supply terminal is connected to V+ and its negative supply terminal is connected to V−, which is actually true ground. An amplifier powered by this supply can process an ac signal symmetrically if the signal input is at ARTIFICIAL GROUND and the constraints of the power supply are not exceeded. The use of a blocking or coupling capacitor at the output of the amplifier permits the recovery of a pure ac signal with no dc component.

A basic bipolar power supply appears in Fig. 1B. The major differences between it and the single-ended supply just described lie in the transformer used, the need for a second filter capacitor, and the lack of a ground-synthesizing voltage divider. A transformer with a center-tapped secondary is needed. The bridge rectifier comprising *D1* through *D4* simultaneously charges filter capacitor *C1* positively and *C2* negatively. The GROUND at the output of the supply is connected to the transformer's center tap, and the positive and negative output voltages are symmetrical with respect to it. Note that the *differential* voltage between the positive and negative supply rails in each supply is the same even though the actual voltages on each of the rails with respect to true ground are not the same.

As a rule, operational amplifiers consume small amounts of current. This points to a disadvantage of the bipolar supply shown in Fig. 1B. Because only a small amount of output current is required, compact transformers rated at 300 mA or less are particularly attractive. Unfortunately, small transformers with center-tapped secondaries are not as widely available as ones lacking a center tap. The bipolar supply shown schematically in Fig. 2 offers a solution to this problem.

A glance at this supply reveals that it delivers positive and negative output voltages by means of a transformer lacking a center-tapped secondary. Also, note that the voltage rating of the secondary is half of that of the transformer shown in Fig. 1B. This supply can be thought of in one of two ways—either as two half-wave supplies, one positive and one negative with a common ground, or as a full-wave voltage doubler. In any event, it provides positive and negative voltages approximately equal to those produced by the supply shown in Fig. 1B. Also, the GROUND at the output of the supply is true ground, not an artificial one.

In practice, the true grounds of Figs. 1 and 2 are often connected to earth ground for shielding purposes. A fundamental difference between the bipolar supplies of Figs. 1B and 2 is that larger filter capacitors are required in the circuit shown in Fig. 2 for the same amount of ripple rejection. This is because the ripple frequency is lower (60 Hz as opposed to 120 Hz). Therefore, twice the capacitance is required if the capacitive reactance of the ripple shunt path to ground is to be kept at the same value as before.

Electronic Filtering. If the current drain from any of the power supplies that have been described is very low, and if the values of the filter capacitors are sufficiently large, only a small amount of ripple will be present in the dc output. However, in some applications even a low-level ripple component can be troublesome. An excellent safeguard against ripple is the use of electronic filtering such as that provided by a zener diode.

If a zener diode or similar component or electronic filtering network is connected to the output of a simple power supply, ripple can be almost entirely suppressed. The diode will provide not only the equivalent of several thousand or tens of thousand microfarads of filter capacitance in a very small space, but also a high degree of voltage regulation, which is very beneficial.

A basic electronic filter for positive-voltage applications is shown schematically in Fig. 3. When a positive unregulated voltage is initially applied to the input of the filter, capacitor *C1* begins to charge up to the input voltage. Zener diode *D1* clamps the voltage across the capacitor when the zener knee of its characteristic curve is surpassed. The voltage applied to the base of transistor *Q1* is thus kept at a fixed level. This transistor effectively performs two functions. It multiplies the capacitance of *C1* by its dc beta and behaves as an emitter follower, presenting a voltage at its emitter equal to the zener voltage less

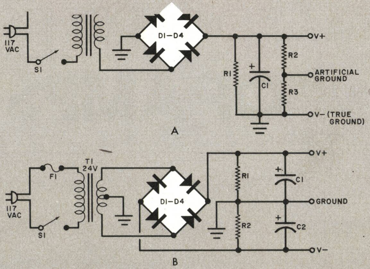


Fig. 1. Single-ended dc power supply for op-amp (A). Bipolar dc power supply that employs a center-tapped transformer (B).

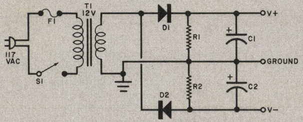


Fig. 2. A bipolar dc supply whose transformer does not have a center tap.

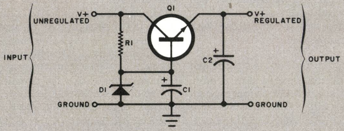


Fig. 3. This electronic filter provides a regulated positive dc output.

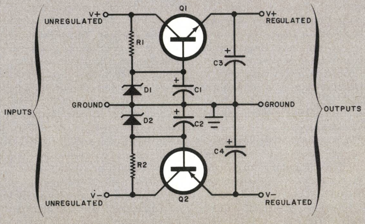


Fig. 4. An electronic filter for use with bipolar dc supplies.

the forward voltage drop across the base-emitter junction. Capacitor *C2* improves the performance of the electronic filter by helping to absorb transients. The time constant *R1C1* results in a slow turn-on characteristic that eliminates potentially troublesome switching transients (clicks) from the supply rails.

The filter shown in Fig. 3 is designed for use with positive-output (negative-ground), single-ended power supplies. It can be adapted for negative-output applications by inverting the polarities of *C1* and *D1* and employing a pnp pass transistor instead of an npn component. The unregulated negative dc voltage would then be applied to the node *R1*-collector of *Q1* and the regulated negative voltage would appear at the emitter of *Q1*. This technique is employed in the bipolar electronic filter shown schematically in Fig. 4. The top portion of this circuit is essentially the same as that shown in Fig. 3, and the bottom is a mirror image of the top—that is, a negative-output electronic filter.

Practical Supplies. A complete bipolar regulated power supply for op-amp audio applications appears schematically in Fig. 5. It is basically an amalgam of Figs. 2 and 4 with a few additional elements included. Hum and ripple components in its bipolar outputs are so low in level that they can be ignored in most applications, even where op amps are operating at high gain. The one precaution that is necessary is careful placement of transformer *T1*. This component should be located as far from high-gain stages as is practicable, and it should be physically oriented to keep induced hum signals as small as possible.

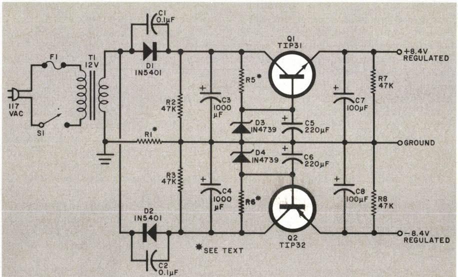


Fig. 5. Complete regulated bipolar supply for op-amp circuits. Transistors Q1 and Q2 might require heat sinking.

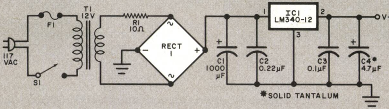


Fig. 6. Regulated single-ended dc supply for powering operational amplifiers.

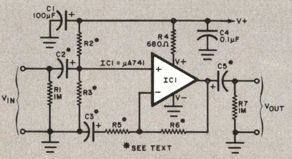


Fig. 7. Typical noninverting op-amp stage designed for use with a single-ended supply.

Rectifiers *D1* and *D2* have forward current ratings of three amperes rms. This high current rating, together with the current-limiting action of *R1*, prevents damage to the diodes by excessive charging current to the capacitors when ac power is first applied to the supply. Actually, the inherent resistance of the 300-mA transformer secondary is great enough to prevent the initial charging current from damaging three-ampere diodes. However, if one-ampere diodes or a transformer with a larger secondary-current rating (and thus less winding resistance) are used, or both, it would be wise to include resistor *R1* in the circuit.

The value of this resistor can be determined by measuring the resistance of the secondary and then solving Ohm's law for the resistance necessary to limit the current through the diodes to the rms rating. The peak voltage delivered by the secondary (1.414 times the rms voltage) should be used in this calculation, and the electrolytic capacitors should be considered dead shorts. Thus, only the inherent secondary resistance and any supplemental resistance provided by *R1* will be available for current limiting. If the resistance value obtained by this calculation is larger than the resistance of the secondary winding, *R1* should be included. Its value is simply the remainder obtained by subtracting the secondary resistance from the total resistance required. This results in a greater degree of protection for the diodes than is really necessary, but ensures trouble-free diode performance.

Note that 0.1-µF disc ceramic capacitors are shown in parallel with each rectifying diode. The function of these components is to suppress the spikes that are generated each time the diode junction breaks into and out of conduction. Fourier analysis of the waveform generated by the diode reveals the presence of significant high-order harmonic components. These harmonics can be troublesome to high-gain op-amp audio stages as well as a source of radio-frequency interference to AM or FM tuners.

Resistors *R5* and *R6* provide current limiting for zener diodes *D3* and *D4*. Values of these components are best determined empirically after performing an initial calculation. First, the rated zener voltage sould be subtracted from the voltage appearing across *C3* or *C4*. The remainder is the voltage drop across the current-limiting resistor. Then Ohm's law should be solved for that value of resistance that results in a current flow of two milliamperes through the resistance. Using this as a starting value, connect a suitable component to the rest of the circuit and temporarily connect a load resistor between the regulated output and ground. The load resistance should be such that the supply will be required to source two or three times the amount of current drawn by the op-amp circuit to be powered under worst-case (maximum current) conditions.

Apply power to the circuit and measure the voltage across the load resistor. Next, disconnect the load from the output of the supply and measure the open-circuit output voltage. If the difference between the loaded and unloaded output voltage is greater than a few percent at most, decrease the value of the current-limiting resistor to the next smaller commercial value and repeat the procedure. (Alternatively, employ a trimmer potentiometer in place of fixed resistors.) When the supply voltage has sufficient regulation, permanently install a fixed resistor of the *next smallest* commercial value with respect to the resistance value that has been empirically determined. This will provide an extra margin of voltage regulation.

The use of this empirical method, though somewhat crude, is justified by the fact that many experimenters purchase surplus zener diodes and transistors whose parameters might be unknown or considerably different from their rated values. Parameters such as a transistor's dc beta and the sharpness of a diode's zener knee will have a significant influence on the appropriate values of the current-limiting resistors. If this method does not produce the desired result, that is, if adequate voltage regulation cannot be obtained, either the zener diode or transistor (or both) should be replaced with another component of the same type. Deficiencies in either device can cause this problem.

Some readers might question the choice of the bipolar output voltage, ±8.4 volts, as opposed to the more common ±12 or ±15 volts. The author was more interested in extended, reliable op-amp performance than in large output-voltage swings. A lower supply voltage places less strain on an op amp and can also help prevent it from becoming noisy. The lower supply voltage does *not* affect stage gain. However, if a higher differential supply voltage is desired, simply use higher-voltage zener diodes for *D3* and *D4* and follow the same resistance-selection procedure that has already been outlined.

Keep in mind that the output voltage will be approximately 0.7 volt less than the zener voltage of the diode and that decreasing the differential input-to-output voltage (V_{CE} of the pass transistor) can degrade voltage regulation when large amounts of current are drawn from the supply. A ±8.4-volt prototype supply can simultaneously power four op-amp audio stages with fine regulation and lack of hum.

A complete single-ended supply for op-amp applications is shown in Fig. 6. It generates a regulated +12-volt output referenced to ground and employs a 100-PIV modular bridge rectifier and an integrated 12-volt regulator. Resistor *R1* limits the surge current through the bridge during power-up. Capacitors *C2* and *C3* are disc ceramic components that should be placed close to the regulator IC package. Solid tantalum capacitor *C4* improves the transient response of the regulator IC. Alert readers might have noted that no spike-suppressing capacitors are shown connected across the bridge's diodes. The capacitors might not be necessary, but any reader who plans to duplicate this circuit should leave space for them if actual performance indicates a need for them. Four capacitors would then be installed—one across each diode forming the bridge.

The +12-volt output is usually sufficient for most op-amp applications. It permits the output of an operational amplifier to swing almost 12 volts peak-to-peak without clipping. If a greater output swing is desired, a higher-voltage regulator IC and either a diode-capacitor voltage multiplier or a transformer with a smaller step-down ratio can be used.

Figure 7 is the schematic diagram of an op-amp audio amplifier that the author has powered with the single-ended supply just described. Resistors *R2* and *R3* form a voltage divider across the supply rails. The values of these components are identical (typically 100,000 ohms) so that the noninverting input of the op amp, the one to which input signals are applied via coupling capacitor *C2*, is at exactly half the supply voltage. This artificial signal "ground" potential permits the op-amp output to swing symmetrically in response to ac excitation. Components *C1* and *R4* decouple the supply line that feeds the biasing resistors to ensure good performance.

The bias level applied to the noninverting input of the op amp causes the output of the amplifier to remain at this same level during quiescence due to the effectively infinite dc feedback provided by *R6*. No dc amplification can occur, however, because *C3* prevents any dc voltage division by *R5* and *R7*. Resistors *R1* and *R6* provide dc return paths at the input and output of the stage.

The amplifier's voltage gain equals the quantity (1 +R6/R5) because the stage is noninverting. Selection of these resistor values is made to obtain the required voltage gain. The capacitance of *C3* should be large enough that the component's capacitive reactance should be low at the lowest frequency to be amplified. One hundred microfarads or more should be sufficient for most audio applications, especially if the gain-determining resistances are on the order of kilohms or more.

Electrolytic capacitors *C2* and *C5* couple ac signals into and out of the amplifier, respectively. Their values have an influence on the frequency response of the amplifier. As a rule, the capacitance of *C5* must be higher than that of *C2* for a given low cutoff frequency because the output impedance of the amplifier is much lower than the input impedance. Practical audio circuits of similar design commonly employ tens of microfarads or more capacitance for input coupling and hundreds or thousands of microfarads for output coupling. The optimum values for a given application depend on the lowest frequency to be amplified, the load impedance, etc.

Some audio circuits employing electrolytic capacitors and op amps powered by bipolar supplies have appeared previously in the literature. These circuits have one principal disadvantage—there is no dc polarizing voltage impressed across the coupling capacitors. During one half of the ac signal cycle, the capacitors are reverse-polarized and a reverse current flow exists. At best, this can result in varying circuit impedances and shortened capacitor useful lifetimes. At worst, it can cause catastrophic capacitor failure and the application of dc levels from a previous stage to a subsequent one. In the op-amp circuit we have just described, all electrolytic capacitors are properly dc-polarized.

In Conclusion. Operational amplifiers are among the most useful devices available to the electronics experimenter. For best performance, their relatively modest power requirements should be satisfied through the use of stable sources of clean dc. To that end, a number of power-supply design ideas and practical circuits have been presented in this article. The experimenter can use them for guidance in the construction of power supplies that will enable him to derive the best possible results from his op-amp projects. ◇

BY ALLEN H. WOLACH

SIMPLE MEMORY ADDITION FOR TRAINING COMPUTERS

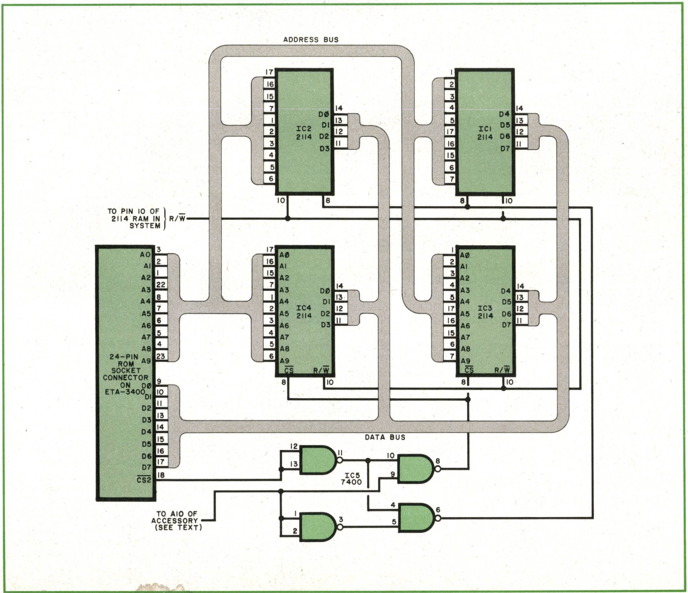
Substitute RAM for ROM

MOST one-board computers, particularly those intended for microprocessor training, contain an operating system and/or a limited high-level language in ROM and some small amount of user RAM. This RAM is usually sufficient to use the system for training purposes; but, after one becomes proficient, the need often arises for more user-memory space. Some systems provide for outboard memory but many do not. Although designed for the Heathkit ET-3400/ETA-3400 Computer Trainer/Trainer Accessory, the memory-expander approach described here can be adapted to other systems.

In this particular system, the Trainer Accessory contains Tiny BASIC in a 2K ROM. If this ROM is replaced with RAM, an additional 2048 bytes of user memory becomes available. If desired, the Tiny BASIC can be recorded on cassette and re-entered at any time using conventional cassette techniques.

Since the ROM is already placed in the system memory map, the address locations for the new RAM are safe. In actuality, the RAM connects to the system via the old ROM socket, thus no extensive wiring is required.

The 2114 static RAMs used in this project are 1K-x-4-bit types that have 1024 addresses with each addressing a



4-bit word. Thus, four 2114 RAMs create a 2048-x-8-bit memory.

In the ETA-3400, Tiny BASIC ROM pins 1 through 8, 22, and 23 are analogous to pins 1 through 7, 15, 16, and 17 of a 2114 RAM. On the ROM, pins 9, 10, 11, and 13 through 17 are the eight data I/O pins, while pins 11 through 14 are the four data I/O pins on the 2114. Pins 21 (CS3) and 20 ($\overline{\text{CS1}}$) on the ROM are chip-select that are placed high (pin 21) and ground (pin 20) in the Heath System. These pins can be ignored since the 2114 RAM uses pin 8 (chip select) that is analogous to pin 18 ($\overline{\text{CS2}}$) on the ROM.

When the ROM is addressed, a circuit within the ETA-3400 decodes address lines A10 through A15 and places a low at $\overline{\text{CS2}}$ (pin 18) when the appropriate high addresses, A10 through A15, occur for any memory locations within the ROM. Since the $\overline{\text{CS2}}$ pin goes low for all 2K locations contained in the ROM, this line must be further decoded so that it goes low separately for the first and last half of the 2K locations. When the decoded input for the first half of the 2K locations goes low, the first half of the replacement 2K RAM is addressed; and, when the decoded input for the second half of the 2K locations goes low, the second half of the replacement RAM is similarly addressed. The complete schematic is shown in Fig. 1.

The modification can be wired on a "solderless socket" having room for four 18-pin 2114s and one 14-pin 7400 TTL chip. Mount the ICs on the board with one unused row of connections between the ICs. Sockets are optional.

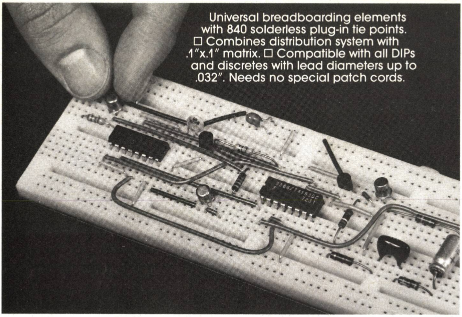
The 24-pin ROM socket connector is formed from a 24-pin DIP header. If such a header is difficult to locate, two 16-pin DIP headers can be suitably cut and cemented together in such a way as to form one 24-pin device.

The upper row of connectors on the solderless socket is connected to pin 24 on the 24-pin header to supply +5 volts to the RAM system. The bottom row of connectors on the solderless socket is connected to pin 12 on the 24-pin header to supply −5 volts (ground). The 2114 RAMs, *IC1* through *IC4*, have their pins 9 connected to the ground line and their pins 18 connected to the +5-volt line. Pin 7 of *IC5* is connected to ground and pin 14 to +5 volts.

The five ICs are wired in accordance with Fig. 1 and connected to the 24-pin header as shown. Use lead lengths long enough to reach the ROM socket in the ETA-3400. The address and data busses shown in Fig. 1 are for the RAM addition and are *not* the system busses. For example, pins 17 of *IC2* and *IC4* are connected to A0 (address line 0) as do pins 1 of *IC1* and *IC3*.

The $\overline{\text{CS2}}$ modification is implemented by *IC5* as shown in Fig. 1. In the Heath system, the line goes low for memory locations 1C00h through 23FFh. Address line 10 in the accessory is high for the first half of these locations (1C00h through 1FFFh) and low for the remaining locations between 2000h and 23FFh. Thus, in the *IC5* stage of Fig. 1, the output from pin 8 is negative for locations 1C00h through 1FFFh while the output from pin 6 is negative for locations 2000h through 23FFh.

Only two connections must be made to the computer accessory. First, pins 1, 2, and 9 of *IC5* are connected (soldered) to A10 on the 40-pin connector of the accessory (pin 18 on the Heath 40-pin connector). Second, the $R/\overline{W}$ pin for the 2114 is pin 10. Interconnect pin 10 of each 2114 then connect them together via a length of wire to pin 10 of any one of the eight 2114 RAMs in the memory accessory. ◇



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CIRCLE NO. 3 ON FREE INFORMATION CARD

TARGET

A new game to play on your Elf computer

BY RON BURCH

THIS short program for the Elf computer plays a game called Target. In this game, 10 "targets" are displayed on the video screen in successive order. The target byte is selected either by keying it in via the hex keypad, or by setting the toggle switches to that byte.

When a target is displayed, the intent is to depress the INPUT switch at that instant. If you were fast enough, the Q LED will glow and 00 will replace the target byte. Play is resumed by depressing the INPUT switch. If you miss the target, the display continues sequencing.

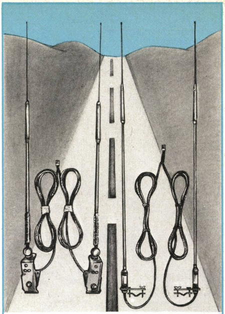
To create the game, enter the program shown in the Table. Addresses 0007 and 0018 limit the number of targets to 10, while addresses 001B and 001E control the speed of the moving targets. If you desire a self-loading 1 to 9 target sequence, replace the first 20 bytes of the program with:

```
F8 A0 A1
F8 00 A2
F8 09 A3
12 82
51 11
23 83
3A 09
C4 C4 C4
```

◇

PROGRAM

Address	Op Code	Address	Op Code
0000	F8 A0 A1		F8 05 B6
	F8 90 A2		26 96
			3A 41
	37 09		37 28
	3F 0B	0047	7B
	E1 6C 64	0048	F8 00 51
	23 83		64 21
	3A 09		37 4D
	F8 A0 A1		3F 4F
	F8 0A A3		7A
	F8 08 B4	0052	30 28
	F8 00 A4		
	64 21		
	24 94		
	3A 22		
0026	30 2F		
0028	11		
	23 83		
	3A 1A		
	30 14		
	E2 6C		
	E1 F5		
	3A 28		
	F8 FF A7		
	27 87		
	32 28		
	3F 38		



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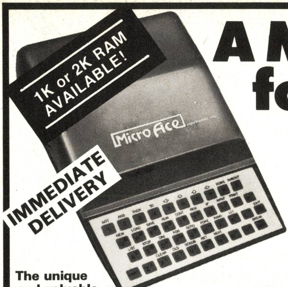

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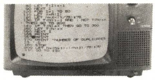

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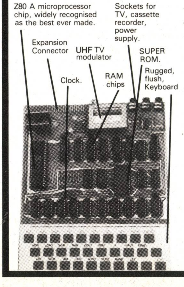
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VARY THE SPEED OF SYNCHRONOUS MOTORS WITH THIS **PROGRAMMABLE CONTROL**

BY GARY McCLELLAN

BECAUSE of their performance, reliability, and relatively low cost, synchronous ac motors are found in many turntables, tape decks, electrical timepieces, and even in the clock drives of amateur telescopes. The rotational speed of such a motor depends largely on the frequency of the ac source that powers it. In most applications, utility-generated ac powers a synchronous motor, making for an operational speed that is accurate and stable but difficult to vary.

Sometimes it is desirable to vary the speed of a synchronous ac motor. This article describes a project, the Programmable Speed Control, that provides this capability. It converts +12-volt dc into line-voltage, square-wave ac whose frequency is crystal-controlled and selectable in 0.1-Hz increments from 10.0 to 100.0 Hz. The project can provide up to 15 watts of output power, and can be modified to provide more. When properly calibrated, it has a rated frequency accuracy six times greater than that of the U.S. ac power grid. The Programmable Speed Control also has a moderate parts count and a relatively low construction cost.

About the Circuit. The heart of the system (Fig 1.) is a phase-locked loop comprising *IC1*, *IC2*, *IC3*, BCD thumbwheel switches *S1* through *S3*, and a quartz crystal. An oscillator in MOS LSI chip *IC1* generates a 3.5795-MHz signal whose frequency is controlled by the quartz crystal *XTAL*. Also included in this chip is a programmable-modulo counter. For this application, the counter is programmed so that a 100-Hz square wave appears at its output. This signal is used as a stable reference input for the phase-comparator section of CMOS phase-locked loop *IC2*.

Applied to the other input of the phase comparator is a square wave derived from the output of the voltage-controlled-oscillator (vco) section of *IC2*. The output of the vco is a square wave whose frequency can vary from 10 to 100 kHz. In the example shown, it is nominally 60 kHz. This signal is applied to programmable-modulo counter *IC3*, which divides its frequency by a factor determined by the settings of thumbwheel switches *S1*, *S2*, and *S3*. These switches generate twelve BCD bits which are applied to the programming inputs of *IC3* and whose decimal equivalent is read off the faces of the switches.

In Fig. 1, the switches are shown set to read 60.0, but the decimal equivalent of the BCD number actually applied to the counter is 600. Accordingly, the vco output frequency is divided by 600, and a 100-Hz square wave appears at the output of *IC3*. The phase comparator accepts the two square-wave inputs. If they are not in phase the comparator sends a dc *error voltage* to the control input of the vco. In response, the vco shifts its frequency of oscillation until the square wave generated by *IC3* is in phase with the quartz-derived reference. (Frequency can be considered the rate of change of phase.) At this point, the output of the vco is phase-locked to the reference.

Switches *S1*, *S2*, and *S3*, together with *IC1*, *IC2*, and *IC3* form a frequency synthesizer that generates an extremely stable square wave. Its frequency will be between 10 and 100 kHz, the exact value determined by the settings of the thumbwheel switches. Counters *IC4* and *IC5* divide the vco output frequency by a factor of 1000. For the example shown, the output of *IC5* is 60.0 Hz. Counter *IC5* functions such that the duty cycle of its square-wave output is 50 percent.

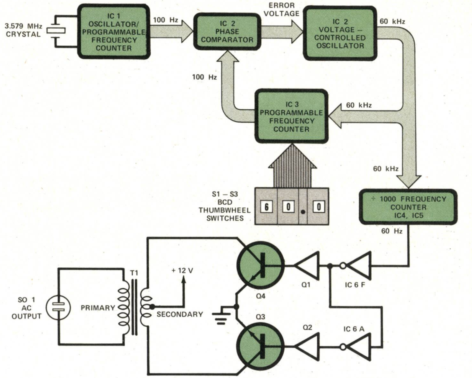
This signal is inverted by buffer *IC6F*, whose output is simultaneously applied to driver *Q1* and to inverting

Crystal-controlled, frequency-synthesized dc-to-ac inverter has many useful applications

buffer *IC6A*. The output of the second inverting buffer is applied to driver *Q2*. When *Q1* is conducting, it provides base drive to power transistor *Q4*, but driver *Q2* and, hence, power transistor *Q3* are cut off. Similarly, when the output of *IC6A* causes *Q2* and *Q3* to conduct, *Q1* and *Q4* are cut off. The emitters of the power transistors are grounded, and their collectors are connected to the ends of the secondary winding of transformer *T1*. The center tap of the secondary is connected to +12 volts.

Power transistors *Q3* and *Q4* cause current pulses of opposite polarity to flow through the secondary of *T1*. Actually, the nominal secondary is used as a primary winding in this application, and vice versa. Line-voltage, square-wave ac appears across the primary of *T1* and is routed to power socket *SO1*. There it is available to the synchronous ac motor whose speed is to be controlled.

The schematic diagram of the Programmable Speed Control (Fig. 2.)


3.579 MHz CRYSTAL
IC 1 OSCILLATOR/ PROGRAMMABLE FREQUENCY COUNTER
100 Hz
IC 2 PHASE COMPARATOR
ERROR VOLTAGE
IC 2 VOLTAGE-CONTROLLED OSCILLATOR
60 kHz
100 Hz
IC 3 PROGRAMMABLE FREQUENCY COUNTER
60 kHz
60 kHz
S1 – S3 BCD THUMBWHEEL SWITCHES
6 0 . 0
÷ 1000 FREQUENCY COUNTER IC4, IC5
60 Hz
T1
+ 12 V
SO 1 AC OUTPUT
PRIMARY
SECONDARY
Q4
Q1
IC 6 F
Q3
Q2
IC 6 A

PARTS LIST

Components denoted by an * are needed only if the optional line-powered supply is built.

C1—30-pF NPO disc ceramic or silver mica capacitor

C2—15-pF NPO disc ceramic or silver mica capacitor

C3—6-to-20-pF air-dielectric trimmer capacitor (E.F. Johnson 275-0320-005 or equivalent)

C4, C6, C8—0.1-μF disc ceramic capacitor

C5—1-μF, 16-volt tantalum capacitor (do not make substitutions)

C7—47-pF NPO disc ceramic or silver mica capacitor

C9—10-μF, 16-V, radial-lead aluminum electrolytic

C10—220-μF, 16-V, radial-lead aluminum electrolytic

C11—2200-μF, 16-V, axial-lead aluminum electrolytic

C12—0.47-μF, 600-V, Mylar tubular capacitor

C13*, C14*—0.01-μF, 250-V, disc ceramic capacitor

C15*—4700-μF, 25-V, axial-lead aluminum electrolytic

D1, D2*, D3*, D4*, D5*—6-ampere, 50-PIV silicon rectifier (Motorola MR750 or equivalent)

F1—2-ampere, type 3AG fast-blow fuse

F2*—1-ampere, type 3AG fast-blow fuse

IC1—MM5369EST MOS LSI oscillator/17-stage programmable counter (National Semiconductor)

IC2—CD4046BC CMOS phase-locked loop

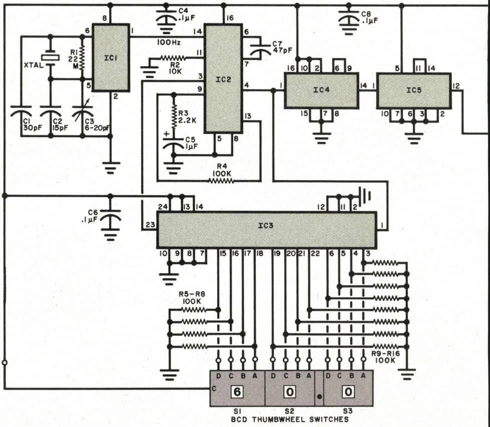


Fig. 2. Schematic diagram of the system. It can provide up to 15 watts of output at SO1, with frequency variable from 10 to 100 Hz.

closely resembles the block diagram. Components *C5*, *R3*, and *R4* comprise a loop filter—a low-pass filter that processes the error-voltage output of the phase-comparator in *IC2*. It ensures that clean dc is applied to the control input of *IC2*'s vco and that the vco's output frequency is stable. A tantalum capacitor is specified for *C5*. Using a standard aluminum-electrolytic capacitor for *C5* can cause circuit instability.

Inverting buffers *IC6A* and *IC6F*, because they are CMOS stages, can source only a few milliamperes of current. Driver transistors *Q1* and *Q2* function as emitter followers and provide base drive for power transistors *Q3* and *Q4*. The amount of base drive, nominally 20 mA, is determined by the values of resistors *R17* and *R18*. It can be adjusted if necessary by changing the values of these components.

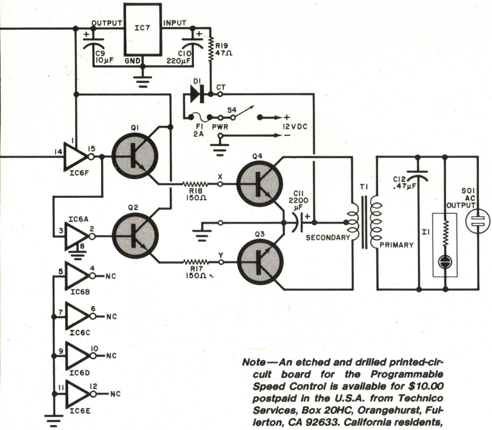
In line-powered applications, synchronous ac motors are driven by a sinusoidal waveform. The output waveform of the Programmable Speed Control, however, is a square wave. Capacitor *C1* is wired in parallel with the transformer's primary winding (functionally the secondary winding) to damp the square wave and to protect the transformer and the synchronous ac motor from transient spikes. Also wired in parallel with the primary winding is neon pilot indicator *I1*. This lamp glows to alert the user that line-voltage ac is present at output power socket *SO1* and that the project is ready for use.

The Programmable Speed Control is designed to be powered by a +12-volt dc source. Diode *D1* protects the polarity-sensitive components in the project from application of reverse-polarity dc. Voltage regulator *IC7* enhances the stability of the frequency synthesizer by isolating it from voltage fluctuations in the dc power source.

Using a dc power source makes the project ideal for applications such as powering the clock drive of an amateur telescope during an outdoor viewing session. However, there are applications for the Programmable Speed Control in which ac line power is readily at hand. Two alternatives suggest themselves. One is to use a 12-volt rechargeable battery connected to a line-powered trickle charger. The other is to use a +12-volt, 3-ampere battery eliminator or the power supply shown in Fig. 3. This unregulated full-wave dc supply is more than adequate to power the circuit. It can be incorporated into the main project enclosure if the Programmable Speed Control will always be used in line-powered applications. Power switch *S4* then becomes superfluous.

Construction. Fashion a printed-circuit board using Fig. 4 as a guide. Referring to the component-placement guide in Fig. 5, install IC sockets or Molex Soldercons at locations *IC1* through *IC6* and add the two bare-wire jumpers between locations *IC2* and *R13*. Next, install the on-board capacitors, observing polarity

(Continued on page 72)



Note—An etched and drilled printed-circuit board for the Programmable Speed Control is available for $10.00 postpaid in the U.S.A. from Technico Services, Box 20HC, Orangehurst, Fullerton, CA 92633. California residents, add state sales tax. Orders from foreign countries must be accompanied by remittance of U.S. currency and a $3.00 postage-and-handling charge.

IC3—CD4059AE CMOS 4-decade programmable counter
IC4—CD4518BC CMOS dual-synchronous BCD up counter
IC5—MM74C90 CMOS 4-bit decade counter
IC6—CD4049C hex inverting buffer
IC7—LM78L05CZ 5-V, 100-mA regulator
I1—Neon pilot indicator with integral series resistor
Q1, Q2—2N3904 npn silicon switching transistor
Q3, Q4—2N3055 npn silicon power transistor
The following are ½-watt, 5% tolerance, carbon-composition fixed resistors.
R1—22 MΩ
R2—10 kΩ
R3—2.2 kΩ
R4 through R16—100 kΩ
R17, R18—150 Ω
R19—47 Ω
S1, S2, S3—Ten-position thumbwheel switch with BCD outputs
S4—Spst toggle switch (not needed if optional line-powered supply is built)
S5*—Spst toggle switch
SO1—Ac power socket
T1—20-V, 1.5-A, center-tapped transformer (Signal Transformer Co. No. 241-6-20 or equivalent)
T2*—25-V, 3-A, center-tapped transformer
XTAL—3.579545-MHz quartz crystal
Misc.—Heat sink, mica insulators, silicone thermal compound, IC sockets or Molex Soldercons, printed-circuit board, suitable enclosure, fuseholder*, pc-mount fuse clips, line cord*, strain relief, power cable, heavy-duty alligator clips (used only if optional line-powered supply is not built), ac power plug*, hookup wire, hardware, solder, etc.

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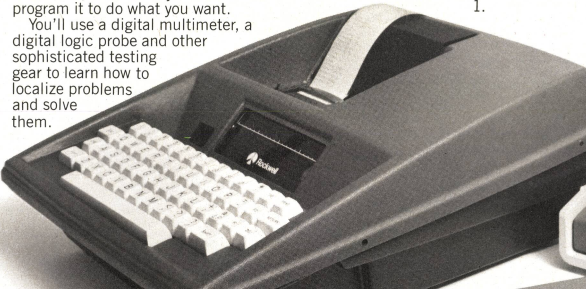

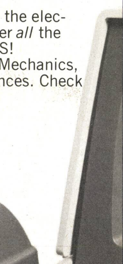

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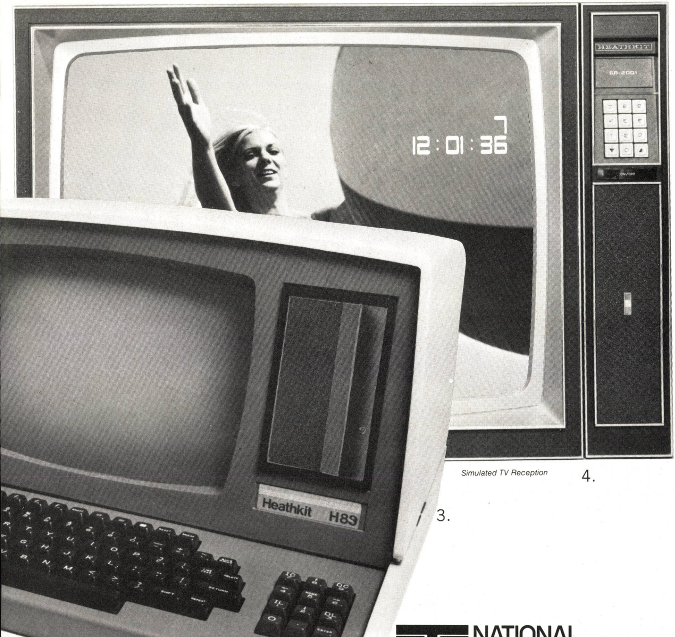

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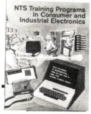
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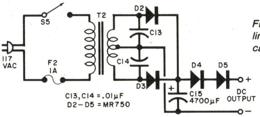


Fig. 3. Schematic diagram of a line-powered supply that can be used with the project.

where appropriate. Make sure to install trimmer capacitor *C3* with the pin connected to the rotor plate and the adjustment screw soldered to the ground foil at the edge of the pc board. Before installing *C5*, double-check that it is a tantalum capacitor—not an aluminum electrolytic.

Next, mount quartz crystal *XTAL*. It might be necessary to drill another hole in the pc board to accommodate one of the crystal's pins. There are many such crystals on the market, and not all have the same pin spacing. Then install regulator *IC7* and transistors *Q1* and *Q2*, making certain their leads are oriented correctly. Use of transistor sockets at these three locations is optional, but will simplify replacement in the event of device failure. Mount copper fuse clips for *F1* and, when they have cooled, snap in the fuse. Install diode *D1* so that its polarity is correct. Finally, mount the fixed resistors on the board.

The remaining components mount off the board and are connected to it by means of flexible, stranded hookup wire or by the attached leads (*T1*, for example). Thumbwheel switches *S1*, *S2* and *S3* are best connected to the pc board using suitable lengths of multiconductor ribbon cable.

When all leads and wires have been soldered to the appropriate pc foil pads, the board should be installed in the project enclosure using standoffs. If a metallic enclosure is used (and this is recommended), it will probably not be necessary to employ heat sinks for power transistors *Q3* and *Q4*. They can be bolted directly to the enclosure using suitable hardware, mica insulating washers, and silicone thermal compound. After the transistors are fixed in place, the leads running from the pc board can be soldered to the appropriate transistor leads. Remember to keep the case or tab of the power transistors isolated electrically from the project enclosure if it is metallic or from any heat sink that is used.

Secure transformer *T1* and power socket *SO1* firmly in place inside the project enclosure. Install a strain relief on the enclosure where the dc power cable leaves it. Connecting large color-coded alligator clips to the free ends of these leads will ease connection to a 12-volt battery.

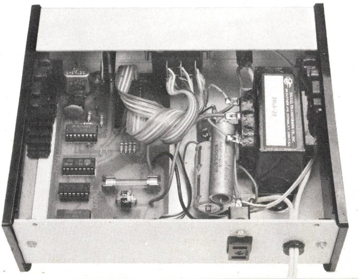
Checkout and Operation. First, plug the device to be controlled into *SO1*. An electric clock is a good test load. Always remember to connect the device to be controlled to the project before applying power to the project. Running the project without a load can damage *C12* or *T1*. Next, set the thumbwheel switches to read "60.0" to select an ac output frequency of exactly 60.0 Hz. Then apply power to the Programmable Speed Control. Upon closure of the power switch, the project should come to life and the clock start to run. If this isn't the case, refer to the "Troubleshooting" section. Compare the operation of the clock with another being powered by the ac line to see how accurate the frequency generated by the Programmable Speed Control is. (Note that two accurate clocks are required for this!) Change the setting of the thumbwheel switches and note how you can apparently speed up or slow down the passage of time.

The Programmable Speed Control can now be used as is or can be calibrated for more accurate output using a frequency counter. Connect the ground of an oscilloscope probe to the case of the project or to circuit ground. Then touch the "hot" side of the probe to pin 7 of *IC1*. Carefully adjust trimmer capacitor *C3* for a reading of 3.579,545 MHz. Then touch the probe to pin 4 of *IC2*, and you should read almost exactly the significant digits of the setting of the thumbwheel switches. For example, if the switches are set for 60.1 Hz, you should read 60.101 kHz. That completes the calibration. It's an optional, but useful step. Uncalibrated, you can expect the project to be accurate to within ±0.01% with the rotor of trimmer *C3* set to midposition. For many applications, that's good enough.

Troubleshooting. Here's a simple procedure you can use to troubleshoot the project. A multimeter and a counter are needed. First, note whether the fuse blows. If it does, disconnect the wire running to board location *CT*. This should stop the fuse from blowing, and reduce the current drain from the dc source to approximately 30 mA.

Measure the voltage on pin 16 of *IC2*. If it is not +5 volts ±5%, suspect *IC7* or the presence of inadvertently created shorts. When the correct reading is obtained, use the counter to measure the frequency at pin 1 of *IC1*. You should read 100 Hz. If you measure 60 Hz and can't obtain the desired ac output frequency, chances are you've used the wrong version of the MM5369! Replace it with the EST-suffix version specified in the parts list. When you've obtained the desired 100-Hz reading, move the counter probe to pin 4 of *IC2* and set thumbwheel switches to read "55.5". The counter should read

Photo of the interior of the author's prototype.



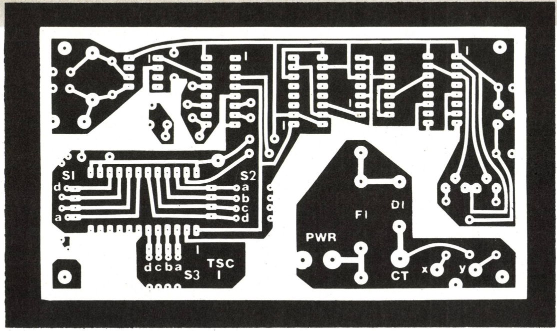


Fig. 4. Etching and drilling guide for a printed-circuit board for the project.

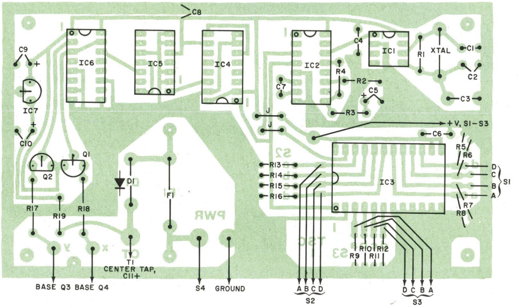


Fig. 5. Use this guide to assemble the components on the printed-circuit board.

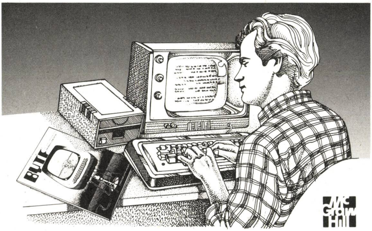
55.500 kHz. If not, check *IC2* and its associated components. Then switch to "60.0." You should read 60.000 kHz. Obtaining any other frequency means that the thumbwheel switches may be miswired or that counter *IC3* is defective.

Once the desired 55.5 Hz is obtained, shift the probe to pin 15 of *IC6*—the reading should be 55.5 Hz. If it is not, *IC6*, *IC5*, and *IC4* are suspect. There should also be 55.5 Hz present at pin 2 of *IC6*, so check it out. At this point, the only problems remaining on the board can be a defective or incorrectly installed transistor at *Q1* or *Q2*. If these components are operating correctly, the problem lies in the off-board section of the project—most likely in *Q3*, *Q4*, or *T1*.

Applications. There are many different applications for this project. Let's detail the few mentioned earlier. Doubtlessly, you'll be able to come up with ones of your own.

A Turntable Speed Controller. The Programmable Speed Control was originally designed for this application, so I have many application hints to offer. First, if your turntable has an incandescent pilot lamp wired in series with the motor like my Empire unit, remove it. The lamp reduces the current flowing through the motor and thus its torque. You'll find that the turntable platter comes up to speed more quickly. Besides changing the turntable speed to correct for off-speed recordings, this project can be used in portable applications.

On the other hand, if you have damaged 78-rpm records that you want to copy on tape, this project can be very helpful. As you might already know, warped 78s will often play at reduced speeds. That's the key to success here. Set your turntable to 45 rpm and the Programmable Speed Control to 50.0 Hz. Then record the music using a tape recorder running at 3¾ ips. When the recording has been completed, play the tape back at 7½ ips, and you'll hear the program



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CIRCLE NO. 5 ON FREE INFORMATION CARD

material being played at normal speed or close to it. Use an equalizer to improve the sound. I've salvaged many "unplayable" 78s this way.

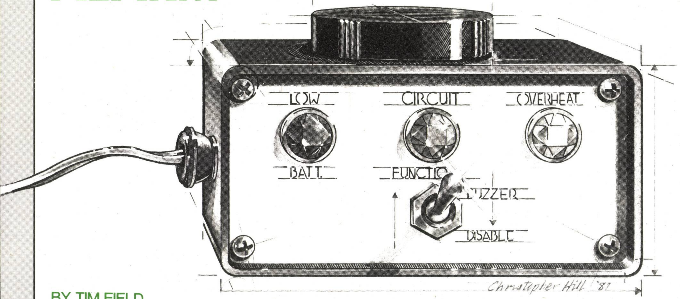
A Tape-Deck Speed Controller. Have you ever played back a tape that was recorded on another machine and noticed a speed difference? This project can compensate for this if the playback deck has a synchronous ac motor that requires no more than 15 watts. You'll probably have to dig inside the deck and isolate the motor from the rest of the power wiring to avoid placing too great a power demand on the project. But the result is that off-pitch tapes can now be played so that they sound right!

A Telescope Clock-Drive Controller. The telescopes owned by most amateur astronomers use synchronous ac motors to keep astronomical objects in their fields of view. Unfortunately, a number of commercially available inverters aren't stable enough to hold the subject of interest in the viewfinder for any period of time. The Programmable Speed Controller is of great help here, as you might expect. It permits fine adjustment of the operation of the clock drive to suit the nature and apparent motion of the object to be viewed or photographed—be it the sun, the moon, a planet, a star, a cluster, a nebula, galaxy or cluster of galaxies.

In this application, the modest current demand (approximately 1.2 amperes) will allow many hours of operation from a motorcycle battery. If you are stargazing in cold weather, keep the project warm before use to minimize drift during the early portion of the viewing session.

If you need more output power from this project, there are things that you can do. A slight increase can be had by decreasing the values of *R17* and *R18*. Right now they provide approximately 25 mA of base drive to power transistors *Q3* and *Q4*. However, don't exceed a dc current drain of 1.5 amperes from the power source or you'll overload *T1*. A heavier-duty transformer can replace the device specified as *T1*—it is a 20-volt, center-tapped transformer rated to handle 1.5 amperes of secondary current. You might use a 12.6-volt, center-tapped, 10-ampere unit and four power transistors (two each connected in parallel using current-balancing resistors) for increased output. It is possible to get up to 100 watts this way. Be sure to use heavy wire for the power cable and transistor wiring if this approach is taken. ◇

FREEZER OVER-TEMPERATURE ALARM



BY TIM FIELD

Warns you if the temperature in your freezer gets above a preset safe level

ONE OF the hazards facing the owner of a well-stocked freezer is the possibility of a "melt-down" of the food. Power failure, a power cord accidentally unplugged, or a mechanical failure could spell catastrophe. This is especially true for freezer units kept in the garage or cellar, where they must operate for extended periods of time without being checked.

Presented here is a simple, inexpensive circuit that will detect when the temperature inside a freezer rises to a predetermined "threshold" point above which the food is in danger. Once this condition is detected, the circuit sounds an alarm. Construction requires less than $15 worth of readily available parts.

Circuit Operation. The Electronic Freezer Protection Unit is shown schematically in Fig. 1. Three-terminal current source *IC4* provides a current that is directly proportional to its absolute temperature. (See Table I for temperature conversion equations.) Flowing through resistors *R7* and *R8*, this current develops a voltage across *R8* that varies linearly with temperature. With V_{cc} greater than 3.3 volts, and *R7* 230 ohms, the voltage across *R8* would be 10 mV/°K. Thus, at the freezing point of water (32°F, 273°K) the output from the sensor will be 2.73 volts.

Note that *IC4* and *R7* can be remote from the remainder of the circuit since the series resistance of the interconnecting leads does not affect the accuracy of the sensor output voltage. Thus, *R7* can be directly soldered to *IC4*. Voltage from the junction of *R7* and *R8* is applied to the inverting input of comparator *IC2A*. The non-inverting input of the comparator is held at 2.49 volts by diode *D3*.

TABLE I
TEMPERATURE CONVERSION EQUATIONS

To convert from:	Fahrenheit	Celsius	Kelvin
To: Fahrenheit	—	(C x 9/5) + 32	(K−273) x 9/5 + 32
Celsius	(F − 32) x 5/9	—	K − 273
Kelvin	(F − 32) x 5/9 + 273	C + 273	—

Examples: Boiling point of water = 212°F = 100°C = 373°K
Freezing point of water = 32°F = 0°C = 273°K

freezer alarm *(cont'd)*

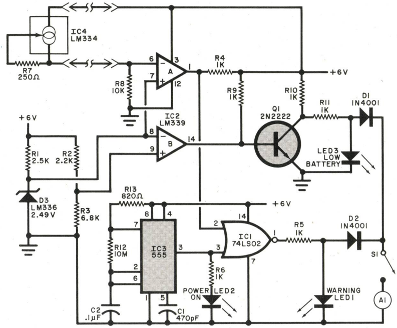


Fig. 1. The three-terminal current source, IC4, provides a current directly proportional to temperature. Both visual and audible alarms are used.

PARTS LIST

A1—Alarm (Radio Shack 273-060 or similar)
C1—470-pF capacitor
C2—0.1-μF capacitor
D1, D2—1N4001 diode
D3—LM336, 2.5-V reference diode (Jameco or similar)
IC1—74LS02 quad 2-input NOR gate
IC2—LM339 quad comparator (Radio Shack 276-1712 or similar)
IC3—555 timer (Radio Shack 276-1723 or similar)
IC4—LM334 adjustable current source (Radio Shack 276-1734 or similar)
LED1—Yelow light-emitting diode
LED2—Green light-emitting diode
LED3—Red light-emitting diode
Q1—2N2222 transistor
R1—2.5-kΩ resistor
R2—2.2-kΩ resistor
R3—6.8-kΩ resistor
R4, R5, R6, R9, R10, R11—1-kΩ resistor
R7—250-Ω resistor
R8—10-kΩ resistor
R12—10-MΩ resistor
R13—820-Ω resistor
S1—Spst switch
Misc.—Four 1.5-V alkaline cells, battery holder, suitable enclosure, two-conductor cable, 2-pin connectors (2), mounting hardware, solder, etc.

In the prototype, it was desired that the alarm sound at about 30° F, so the value of *R7* was adjusted to set the voltage across *R8* at 2.49 volts at 30°F. The exact value of *R7* was found to be 253 ohms, but the closest standard value was used. Comparator *IC2A* gives a low output when the sensor temperature exceeds the predetermined freezer temperature, and a high when the freezer temperature is safe.

Battery voltage is fed to the noninverting input of comparator *IC2B* via *R2* and *R3*, while the inverting input is coupled to the 2.49-volt reference diode. As long as the battery voltage is high, the output of *IC2B* is high. Transistor *Q1* is kept in saturation by *R9*. Thus, the voltage at its collector will be too low to turn on Low Battery warning *LED3*. When the battery voltage drops, comparator *IC2B* outputs a low, which turns *Q1* off, raising its collector voltage high enough to turn on *LED3*, forward bias diode *D1*, and, if switch *S1* is closed, operate the alarm (*A1*).

Timer *IC3* is connected as an oscillator that is always running. *LED2*, via its associated current limiter *R6*, flashes at the oscillator rate to indicate that the system is powered. The output of *IC3* (pin 3) is connected to one input of 2-input NOR gate *IC1*. The other input to this gate is from *IC1A*, the comparator in the temperature sensor circuit. When both inputs to NOR gate *IC1* are simultaneously low, the output is high. Thus, when the freezer temperature is at the critical level and the output of *IC2A* goes low, the output of *IC1* alternates at a frequency determined by *IC3*. When *IC1* output is high, warning indicator *LED1* flashes, and when switch *S1* is closed, alarm *A1* is operated via isolation diode *D2*. Since the output of *IC1* alternates, both the LED and alarm are turned on and off to attract attention. Switch *S1* is used to silence the alarm when required, but the warning light will still function.

Construction. Since component placement is not critical, any form of interconnection can be used to build the circuit—or a small pc board can be designed and fabricated. Resistor *R7* is mounted directly to *IC4*, and the two connections to this sensor are made via a 2-pin connector. This assembly is placed within the freezer, and a length of two-conductor cable connects the sensor with the remainder of the circuit.

The main circuit can be mounted in a 1.5" x 2.5" x 5" plastic enclosure, and the four 1.5-volt series-connected dry cells in a battery holder. If desired, a 6.5-volt line-operated power supply can be used as shown in Fig. 2. Normally, the output voltage of the power supply is higher than the battery voltage, reverse-biasing the diode and keeping the battery out of circuit. If the power line fails, the battery forward-biases the diode and feeds the circuit until line power is restored. The warning circuit will operate for about three months on conventional alkaline cells alone.

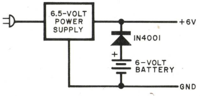


Fig. 2. This power supply can be used in addition to batteries if desired.

Use. Position the main section of the alarm where you are certain to see and/or hear it should it trip. Place the sensor inside the freezer and connect it to the main section with a length of 2-conductor cable. (Resistor *R7* is large enough to make the actual length of any reasonable wire run noncritical.) If your alarm is line-powered, plug it in. Then stop worrying about your frozen food. ◇

CANCEL RUMBLE WITH THIS BASS-SUMMING AMPLIFIER

Versatile project can also be used as an electronic crossover for a subwoofer power amp.

BY JOHN H. DAVIS

THE presence of deep bass in the output of an audio system adds a satisfying "floor" to reproduced program material. However, designing a system to reproduce low frequencies well heightens the probability that rumble will make itself disconcertingly apparent. Presented here is the Bass Summing Amplifier, a project that can attenuate rumble without adversely affecting the low-frequency content or the high-frequency separation of a phonograph disc. It can also be used as an electronic crossover that sums the extreme bass to feed a subwoofer power amplifier. The Amplifier is easily and inexpensively constructed and requires no critical components or adjustments.

Rumble is low-frequency noise that is generated by phonograph recording and playback equipment. High-pass filtering can attenuate subsonic noise to a large extent, but it can't suppress audible rumble without also removing some desired bass content.

Most of the rumble entering a phono cartridge does so as vertical modulation that results in out-of-phase electrical signals at the phono cartridge's outputs. If these low-frequency out-of-phase signals are combined, they will cancel each other. Since recordings contain little or no out-of-phase, low-frequency information, low-frequency summation does not appreciably degrade the program material. What little bass separation exists and is recorded is not audibly significant to human beings. Psychoacoustic studies indicate that bass localization is mostly a function of attack transients and overtones.

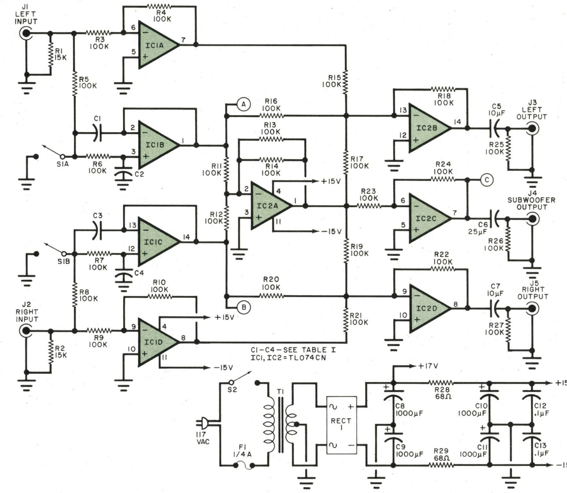
To verify that bass summing will attenuate rumble, play a silent groove on a vinyl disc and increase the volume until the rumble can readily be heard. Then switch your amplifier or preamplifier to its monaural mode. If your left and right channels are balanced and in proper phase, you will hear a drop in the rumble level.

About the Circuit. A schematic of the Bass Summing Amplifier appears in Fig. 1. Line-level stereo inputs are applied to jacks *J1* and *J2*. Unity-gain inverters *IC1A* and *IC1D* shift the phase of the input signals by 180°. However, the unity-gain, low-pass filters comprising *IC1B*, *IC1C* and their associated passive devices do not appreciably alter the phase of those components of the input signals below their cutoff frequencies. If the outputs of *IC1A* and *IC1B* and those of *IC1C* and *IC1D* are combined, the low frequencies will cancel, leaving inverted midrange-and-treble stereo signals.

If the bass outputs of *IC1B* and *IC1C* are combined, a composite, summed bass signal results. This summed bass contains all of the in-phase information but no difference information. If this composite bass is recombined with the middle-and-high-frequency stereo signals, the resulting stereo outputs are almost indistinguishable from the original—except for the lack of rumble components. Because the operation of *IC1A* and *IC1D* involves phase inversion, *IC2B* and *IC2D* perform an additional compensating inversion.

The performance of the project in the rumble-suppressing mode is summarized by the graphs of Fig. 2. The heavy curve shows the extent to which low-frequency difference information is cancelled when the low-pass filters have cutoff frequencies of 220 Hz. The lighter-weight curve shows the extent to which channel separation is maintained as a function of frequency. Two dashed curves show the measured separation available from modestly priced and premium phono cartridges. These latter curves demonstrate that, above bass frequencies, the project does not adversely affect realizable separation.

A monaural signal that can be used to drive a subwoofer power amplifier is available at the output of *IC2C*. This filtered and summed bass signal is in phase with respect to the bass components of the stereo input signals. However, in this application, resistors *R17* and *R19* must be deleted so that the summed bass is not also present in the stereo outputs. Accordingly, the stereo system handles only the upper bass, midrange, and high frequencies. Figure 3 shows the low-pass-filter response that characterizes the output presented at *J4* for a cutoff frequency of 110 Hz. The stereo out-



PARTS LIST

Components denoted by an asterisk can be deleted if the optional, dynamic separation indicator is not to be built.

C1,C2,C3,C4—Metallized polyester, metallized Mylar, monolithic ceramic or polystyrene capacitor, 10% or closer tolerance (see Table I for capacitance)

C5,C7—10-μF, 50-V, axial-lead, nonpolarized electrolytic

C6—25-μF, 50-V, axial-lead, nonpolarized electrolytic

C8,C9,C20*—1000-μF, 25-V, radial-lead electrolytic

C10,C11—1000-μF, 25-V, radial-lead electrolytic

C12,C13—0.1-μF, 50-V disc ceramic capacitor

C14*,C15*—0.033-μF, 100-V Mylar capacitor

C16*,C17*—0.33-μF, 35-V tantalum capacitor

C18*,C19*—0.68-μF, 35-V tantalum capacitor

C21*—0.15-μF, 100-V Mylar capacitor

C22*—0.001-μF, 100-V Mylar capacitor

D1*,D2*,D3*—1N300 silicon switching diode

D4*—1N4001 rectifier

F1—1/4-ampere fast-blow fuse

IC1,IC2,IC3*—TL074CN quad BiFET operational amplifier

IC4*—LM324N quad operational amplifier

J1 through J5—RCA phono jack

LED1*—Red light-emitting diode

LED2*,LED3*—Green light-emitting diode

The following, unless otherwise specified, are 1/4-watt, 5% tolerance, carbon-film fixed resistors.

R1,R2—15 kΩ

R3 through R27, R30* through R35*, R41*, R42*—100 kΩ (see text for recommended preselection procedure)

R28,R29—68 Ω, 1/2-watt

R36*,R37*,R44*—22 Ω, 1/2-watt

R38*—330 kΩ

R39*—120 kΩ

R40*—82 kΩ

R43*—27 kΩ

R45*,R46*,R47*—680 Ω

RECT1—1-A, 100-PIV modular bridge rectifier

S1—Dpdt switch

S2—Spst switch

T1—24-V, 300-mA, center-tapped step-down transformer

Misc.—Printed-circuit board, standoffs, suitable enclosure, fuseholder, line cord, shielded cable, hookup wire, suitable hardware, strain relief, solder, etc.

Note—The following is available from M. H. Marks Enterprises, 315 Thornberry Court, Pittsburgh, PA 15237: complete kit of parts (less enclosure and hardware), No. BSA-3, for $44.95 plus $3.00 shipping and handling within U.S.A. Also available separately: etched, drilled and silkscreened printed-circuit board, No. BSA-PC, for $12.95 postpaid within U.S.A. Allow six to eight weeks for delivery. Pennsylvania residents, add 6% state sales tax.

puts presented at *J3* and *J5* have complementary (high-pass) responses.

For those who want reassurance that difference information cancelled along with the rumble is audibly insignificant, an unusual, dynamic separation indicator is presented as an option. It responds primarily to the frequencies affected by the bass-summing process, and is shown schematically in Fig. 4. The design of this indicator is based on the fact that separation is reflected as an increase in the level of difference information relative to the level of in-phase information. Differential amplifier *IC3A* processes the filtered right- and left-channel bass signals to obtain differ-

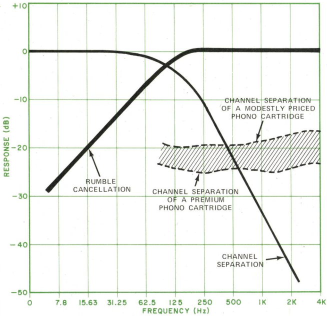


Fig. 2. Performance curves for low-pass-filter cutoff frequency of 220 Hz. Heavy curve shows the extent to which difference information is suppressed as a function of frequency.

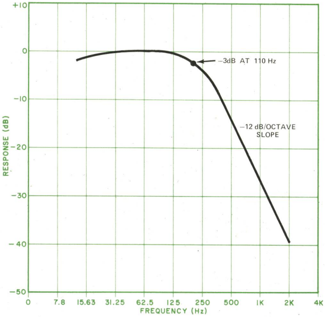


Fig. 3. Low-pass-filter response that characterizes the subwoofer-output channel. Stereo-output channels have a complementary, high-pass characteristic.

ence information. The output of *IC3A* is rectified by *IC3B* and *D1*, and charges *C18*.

Summed bass is available at the output of *IC2C* (point C in Fig. 1). It is brought up to an equivalent level by amplifier *IC3C*. The frequency response of this stage is shaped by capacitors *C21* and *C22* to attenuate the unwanted higher frequencies. The amplified, summed bass output of *IC3C* is rectified by *IC3D* and *D2*, and charges *C19*.

Comparators *IC4A*, *IC4B*, and *IC4C* compare the two resulting dc levels and light *LED3*, *LED2*, and *LED1* at progressively higher levels of separation. The network comprising *D3*, *D4*, *R43* and *R44* maintains a small bias voltage across *C19*. This prevents random triggering of the comparators by noise at low signal levels. Such triggering would otherwise be troublesome because signal comparison is based on ratios, not fixed voltage levels.

Options and Modifications. Before undertaking construction, you should determine exactly what function(s) you want this project to perform. If you want only to suppress rumble, you will probably want a filter cutoff frequency of 220 Hz (330 Hz if the rumble is severe). Table I shows which values of capacitors and resistors to use for these frequencies. Also listed are component values for a cutoff frequency of 110 Hz, which is a better choice if a subwoofer is used.

TABLE I
VALUES OF FILTER COMPONENTS FOR SELECTED CUTOFF (−3-dB) FREQUENCIES

Frequency	Recommended Application	R5, R6, R7, R8	C1, C3	C2, C4
110 Hz	Rumble suppression and subwoofer crossover	100 kΩ	0.02 μF	0.01 μF
220 Hz	Rumble suppression	100 kΩ	0.01 μF	0.005 μF
330 Hz	Suppression of severe rumble	68 kΩ	0.01 μF	0.005 μF

In a Bass Summing Amplifier to be used for rumble reduction only, there are a few components which *can* be eliminated (*C6*, *J4*, and *R26*). To drive a subwoofer power amplifier in addition, however, two resistors (*R17* and *R19*) *must* be deleted. Whether the project is used for both purposes or only for rumble suppression, you have the option of including the separation indicator. If you choose not to include it, some parts can be deleted. They are denoted by an asterisk in the Parts List.

Construction. There are no high-gain or other stages in which circuit layout is critical. However, the use of a printed-circuit board is recommended because of the rather high parts count. The full-size etching and drilling guide for a suitable pc board appears in Fig. 5. Its corresponding component placement guide appears in Fig. 6. The use of IC sockets or Molex Soldercons is recommended.

There are a few points to consider concerning component selection. To minimize distortion, the capacitors in the low-pass filters (*C1* through *C4*) should be metallized plastic-film or other high-quality components. For the same reason, *C5*, *C6*, and *C7* should be nonpolarized electrolytics. Purists will also want to connect 0.1-μF metallized plastic-film capacitors in parallel with *C5*, *C6*, and *C7*.

Carbon-film, 5%-tolerance resistors are acceptable for use in this project, but a simple preselection procedure requiring only an ohmmeter is recommended. The ohmmeter need not be particularly accurate, but should allow you to resolve slight differences in resistance around a center value of 100 kilohms. Exact values are not as important as close matches.

First, measure the values of some 100-kilohm resistors and set aside four that match very closely for *R15*

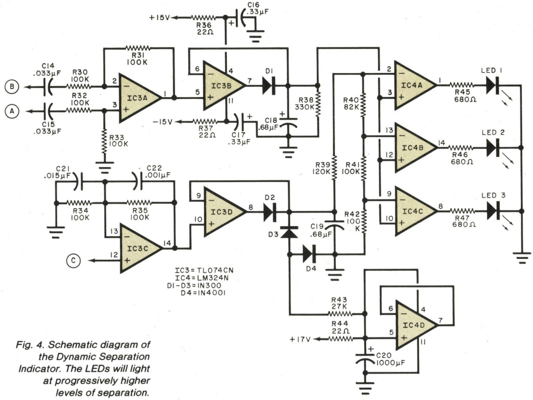


Fig. 4. Schematic diagram of the Dynamic Separation Indicator. The LEDs will light at progressively higher levels of separation.

through *R18*. Select another matching group of four as *R19* through *R22*. Select a third group of four as *R11* through *R14*. Finally, select two closely matched pairs, one pair for *R3* and *R4*, the other for *R9* and *R10*.

The project will perform reasonably well even if this process is not followed, but the more closely matched in value the members of a given group, and the closer the tolerances of *C1* through *C4*, the smoother the frequency response.

When mounting the components on the printed-circuit board, take note of device orientation and the presence of the two short jumpers at pins 5 and 10 of *IC1*. Also note that *R1* and *R2* are soldered across each of the input jacks—they are not mounted on the board. Similarly, *R25*, *R26*, and *R27* are soldered across the appropriate output jacks. The project should be housed in a metal enclosure with shielded cable connecting the pc board to the input and output jacks and switch *S1*.

Testing. Doublecheck the circuit assembly. Then apply power and verify that the positive and negative supply voltages are equal and less than 18 volts. A one-volt, 30-Hz signal applied to *J1*, the LEFT INPUT jack, should result in the appearance of half-volt signals at both *J3* and *J5*, the LEFT and RIGHT OUTPUT jacks. If the project has been built for subwoofer use, the half-volt signal should appear at *J4*, the SUBWOOFER OUTPUT jack, *only*. If a 30-Hz, one-volt signal is applied to *J1* and *J2* simultaneously, the outputs at *J3* and *J5* or the output at *J4* should increase to one volt.

If you have built the dynamic separation indicator, you can test its operation by applying a 30-Hz signal. When the input signal is applied to either *J1* or *J2* (but not both), all three LED's should glow. Ideally, they should all extinguish when both channels are driven by the same input signal. Check to see if this happens.

Next, change the frequency of the test signal to 3000 Hz but keep its amplitude at one volt. Apply this signal to *J1*. A one-volt signal should now appear only at *J3*. Then apply the signal to *J2* and verify that an output appears only at *J5*. At this frequency, none of the LEDs should glow, even if only one channel is driven. If *LED3* does glow, decrease the level of the input signal to see if it extinguishes. (These statements assume, of course, that *S1* is open.)

AUTHOR'S SPECIFICATIONS

Input Impedance: 10 KΩ

Recommended Load Impedance: 10 kΩ or greater

Input-signal Level: 0.3 to 3.0 volts rms; 1.0 volt recommended

Total Distortion: Less than 0.05%

S/N: Better than 70 dB (unweighted)

Frequency Response: 50 Hz to 16 kHz ± 1/4 dB at stereo outputs with *R17* and *R19* in project; filter resistors preselected according to procedure described in text; both channels driven, *S1* open.

If you don't have access to test equipment, you can patch the project into your system at a line-level point in the signal chain. The Bass Summing Amplifier should be connected *after* any signal-processing components such as an equalizer, a dynamic-range expander, etc. Then find a quiet groove on a vinyl disc and play it. Listen for rumble, and open and close switch *S1*. A difference in the rumble level should be noticeable. During such a test, *LED3* might flicker, but the other two LEDs should flash only very rarely.

Use. For the Bass Summing Amplifier to function properly, your audio system needs to be well balanced at the point at which signals are routed to the inputs of the Bass Summing Amplifier. Use the monaurally recorded bands of a test record, or listen to a quiet groove of a standard disc

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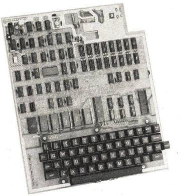

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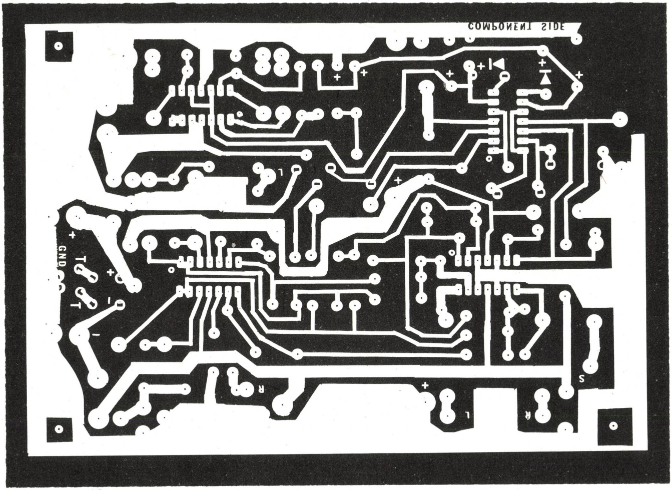

Fig. 5. Full-size etching and drilling guide (above) for the Bass Summing Amplifier and Dynamic Separation Indicator.

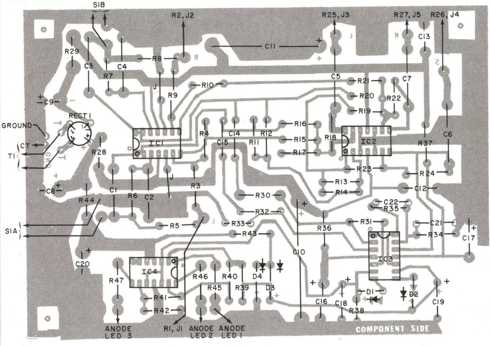

Fig. 6. Component placement guide to be used with the printed-circuit board.

while adjusting interchannel balance. Maximum cancellation occurs when the channels are exactly balanced. Even high-quality phono cartridges have some imbalance, and as much as 2 dB will degrade the rumble-cancelling capability of the project.

The net result of your efforts will be quieter and more satisfying bass. As a bonus, the bass summing amplifier can be used to reduce rumble on tapes that have been dubbed from noisy turntables or from FM broadcasts generated using outdated studio equipment. ◇

EXPERIMENTER'S CORNER

By Forrest M. Mims

Electronic Aids for the Handicapped

ONE of the most rewarding activities that an electronics experimenter can pursue is the design and construction of electronic aids for the handicapped. The Telephone Pioneers of America know this as well as anyone. For many years, members of this organization have designed and built electronic aids for handicapped people, such as softballs that emit a beeping sound for blind children.

Many companies and a few foundations manufacture various electronic aids for the handicapped. Some of these, such as the reading machines for the blind made by Telesensory Systems, Inc., are amazingly sophisticated. They are also expensive.

Prosthesis (pros-thē′-sis) is the technical term for an electronic or mechanical substitute or supplement for a missing or defective part of the body. Many people in need of prostheses are not aware that they exist. For example, I recently observed an elderly blind man attempting to cross a busy street. While helping him across, I informed him that his cane was far too short—he could place it less than a foot in front of his extended foot. He was delighted to learn that *long* canes are readily available.

Many people have a hearing deficiency that can be readily alleviated with the help of a hearing aid. But eyeglasses, which constitute a vision prosthesis, are more readily accepted than hearing aids.

This month, we'll look at several kinds of prostheses that you can make. First, let's consider a valuable service you can probably render to hearing-aid users.

Repairing Hearing Aids. Much of my early education in solid-state electronics was gained by repairing defective hearing aids obtained from dealers for a few dollars or less. I quickly learned that most would work properly when the power switch, earphone jack (if present), battery contacts, or volume control was cleaned with a tiny spurt of solvent spray. Sometimes a frayed earphone cord was the culprit, but this only occurred in "body aids." Most aids of contemporary design are worn in or behind the ear and include an integral transducer acoustically coupled to the ear by means of a plastic tube.

Originally, I converted the repaired aids into miniature transistor radios. This was readily accomplished by removing the microphone and installing in its place a tuned circuit made from a miniature ferrite-core coil and a disc capacitor. I used a germanium diode to demodulate the signal.

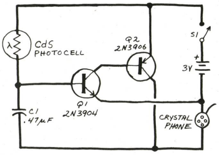

Fig. 1. Simple transistorized light probe for the blind.

During college days, I derived material benefit from repairing damaged and defective hearing aids for a local dealer for $5.00 each. Considering the replacement cost of such devices (often hundreds of dollars or more), the fee was a bargain.

You can easily put together a repair kit to help you solve most common hearing-aid problems. You'll need facial tissue, cotton swabs and alcohol to clean accumulated debris from the exposed portions of the aid. An ink eraser or other abrasive surface (e.g. very fine finishing paper) is handy for cleaning battery contacts. A small can of TV-tuner contact cleaner with a thin spray tube or nozzle is needed to clean switch contacts, phone jacks and volume controls.

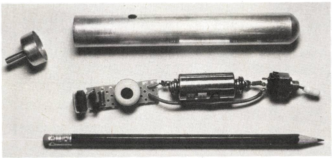

Fig. 2. Construction of a light probe in a cigar tube.

Sometimes, switch contacts fail to engage completely. A pair of high-quality, midget needle-nose pliers or a pair of pointed tweezers can help you remedy this problem. A small hand lens and a portable desk lamp will make it easier to find problems and see what you're doing. You'll also need a multimeter to check batteries and to test the continuity of switch contacts and earphone wires.

Your kit will be complete with the addition of a set of jewelers screwdrivers and a miniature, low-wattage soldering iron. You can put everything in a small fishing-tackle or tool box. The kit can also be used for much of your experimental work.

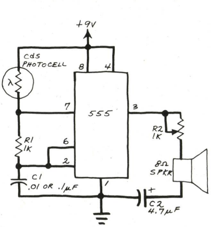

Fig. 3. A 555 light probe with high-volume output.

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You must gain experience troubleshooting and repairing discarded hearing aids before attempting to repair a person's only audio link with the outside world. Hearing aids are very fragile and usually very expensive, so you must exercise considerable care when attempting to repair them. Other than minor cleaning, leave the repair of units under warranty to the dealer or the manufacturer.

Spare parts can be expensive and difficult to find. You can sometimes salvage parts from discarded aids. New components can be ordered from hearing-aid manufacturers or distributors. A local hearing-aid dealer might provide you with addresses or let you look through his parts catalogs. Be aware, however, that many dealers do not repair aids and therefore will not have such information.

You can donate salvaged aids you have repaired to a hospital, nursing home, or a nonprofit society for the deaf. This can provide you with a tax deduction (charitable gift) which will help finance future projects. After you've become proficient at repairing discarded aids, you can try repairing aids in everyday use. Call a local nursing home or hospital to find out about aids which need service.

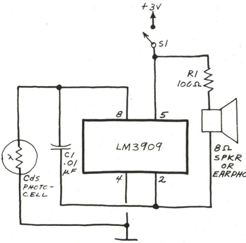

Fig. 4. A light probe circuit using an LM3909.

Do-It-Yourself Prostheses. It's relatively easy for experimenters to design and assemble prosthetic devices for blind and deaf people. You might also be able to build various kinds of remote-control devices that will enable immobile or paralyzed people to turn on a light, radio, television and other device from a fixed location. Let's examine some possibilities.

Aids for the Blind. Probably the simplest gadget you can build for a blind friend or relative is a light probe that produces a sound when a photodetector is illuminated. Light probes date from 1912 when British scientist Fournier d'Albe built a device he called the "Exploring Octophone." It employed a selenium cell in a Wheatstone bridge and generated a musical tone as light intensity was varied.

You can build an updated version of d'Albe's light probe (Fig. 1). This circuit, which I described in a previous article ("Build a Light Probe," POPULAR ELECTRONICS, March 1973, pp. 42-43), can be easily installed in an aluminum or plastic cigar tube (Fig. 2).

The circuit is a two-transistor regenerative amplifier. Its frequency of oscillation depends on the amount of light striking the sensitive surface of the cadmium-sulfide photocell.

Audio output is supplied by a crystal earphone that serves as a miniature speaker. The volume is sufficiently high so that the user can hear the tone, but it is not so loud as to distract nearby persons.

The probe can be made much smaller than the unit shown in Fig. 2. Several years ago, I built a probe, complete with mercury button cell and hearing-aid receiver, into a small plastic tube measuring about 3/8" x 1". This was made possible by the tiny but surprisingly effective hearing-aid receiver unit I used in its construction. I intended to attach the probe to a key chain but, because of its small size, I promptly misplaced it.

There are many ways to make circuits which produce a tone whose frequency is dependent upon light. Figure 3, for example, is an IC version designed around the readily available, inexpensive 555 timer. This circuit is very sensitive and can be adjusted to provide various frequency ranges and threshold levels, but it consumes more current than the circuit shown in Fig. 1.

An important advantage of the circuit in Fig. 3 is that it can provide more drive current to a small speaker or other transducer than the transistor circuit. This may prove a significant advantage to blind people with a hearing problem, a not uncommon combination among older individuals.

Still another light probe circuit is shown in Fig. 4. This circuit uses the amazingly versatile LM3909 LED flasher chip as a light-controlled audio oscillator.

Light probes have many practical applications. Blind telephone operators have used them to find illuminated indicator lights on a switchboard. Such probes can also be used to determine if room lights are on or off, whether or not appliances with pilot lights are on, and to find color changes on clothing and wall surfaces.

Another simple but very useful aid for blind people is a liquid-level indicator. A blind person usually determines when a cup or glass has been filled by keeping a finger tip inside the rim of the container while pouring the liquid. This procedure can be uncomfortable if the beverage is hot and can be unseemly if sighted guests are being served.

The "Project of the Month" in this issue describes a very simple two-tone liquid-level indicator which is essentially identical to the light probe in Fig. 4. Indeed, you may wish to build an LM3909 oscillator with a phone-jack input port. You can then connect either the liquid-level probes described in the "Project of the Month" or the photocell as in Fig. 4.

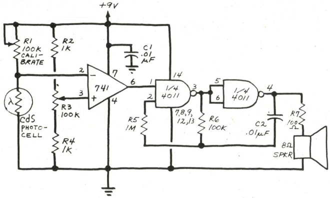

Fig. 5. Color detection circuit for urinalysis.

Partial or even total loss of vision can be an unfortunate side effect of advanced diabetes. A modification of the light-probe concept can be used to help blind diabetics perform their own tests of the sugar level in their urine.

Urinary sugar content is ordinarily determined by dipping a strip of test paper into a specimen. Color changes in the paper denote the sugar level. You can detect the color of a test strip by making a light-tight chamber fitted with a cadmium-sulfide photocell and a small lamp. When a test strip is placed in the chamber, the resistance of the photocell will be determined by the color of the strip.

I built a urine-monitoring device similar to this in 1966, and at least one such device is commercially available today. If you want to assemble one for a blind diabetic, spend the time to calibrate it carefully. Make sure the unit can be reliably operated by a blind person. Erroneous readings from the unit could prove extremely hazardous to a person who uses it.

To experiment along these lines, Fig. 5 is the schematic of an elementary circuit with which you can get started. The operational amplifier, operated without a feedback resistor so that it functions as a comparator, has its switching threshold determined by the setting of *R3*. The photocell is one section of a voltage divider. When the divider output reaches the switching threshold set by *R3*, the comparator actuates the tone generator made from two of the gates in a 4011.

In using this circuit, the photocell is pointed at an illuminated test strip (you can obtain test paper at a pharmacy). The output of the divider is a voltage representative of the reflectance of the strip. Potentiometer *R3* is then adjusted until the tone is heard. Raised markings at predetermined points form a scale for the control knob, which should have a stubby pointer, that a blind person could "read" easily.

Aids for the Deaf. We've already discussed the repair of hearing aids. In a pinch, you can actually *make* a usable hearing aid from a miniature audio-amplifier circuit or a low-cost portable, commercial amplifier and a microphone and earphone. This assembly will be much bulkier than an ordinary hearing aid, and it will pick up rustling clothing noises unless the microphone is mounted in an unobstructed location. It will also be much more subject to acoustic feedback and oscillation, which can be frightening. Such an aid will not necessarily be as good for the amplification of audio frequencies as are the specialized designs of most hearing aids. Nevertheless, it can prove very helpful in an emergency or when a person's hearing aid is being repaired.

The totally deaf cannot be helped by conventional hearing aids. Ways to signal such people include a light panel, CRT display, or printer.

A simple yes-no signalling system can be made with a tactile stimulator. Such devices can be made from piezoelectric substances which, when electrically stimulated, vibrate or poke against the surface of the skin. A more homely but simpler approach that rarely fails to get a person's attention is an eccentric weight attached to the shaft of a small dc motor. When the motor spins, the vibrations generated by the offset weight is easily felt,

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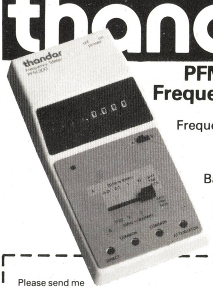

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SOLID-STATE DEVELOPMENTS

By Forrest M. Mims

Amber and Lodestones and Other Topics

THE primary purpose of this column is to cover *new* developments in solid-state electronics. From time to time, however, I would like to describe the historical discoveries which led to the development of the wonderful variety of electronic components and circuits available to us today. Paying tribute to those who made modern electronics possible—and reflecting upon the simple, often crude, methods, instruments, and components they used—helps one to appreciate how far we have come. This month, let's examine the uncovering of phenomena that led to the eventual discovery of electricity.

Magical Minerals. The beginning of this long process can be traced to two naturally occurring substances that exhibit very unusual properties. The substances are *amber* and *magnetite*. Their ability to attract bits of straw and particles of iron, respectively, has been observed since the beginning of recorded history.

In my desk drawer is a small chunk of magnetite from Utah which I purchased at a gem-and-mineral show for 50¢. The mineral, which is commonly called *lodestone* or *loadstone*, is an iron ore that has a generally metallic appearance.

That my piece of magnetite is magnetic is obvious from the whiskers of iron filings projecting from it. A small finishing nail that clings to the lodestone has itself become magnetized, and some iron filings cling to it when it is pulled from the lodestone.

Also in my desk are several pieces of transparent, golden-yellow amber. Amber is fossilized tree sap, and my specimens contain several small entrapped fungus gnats which are easily seen with the help of a small lens. If the amber is rubbed briskly with a piece of flannel, it will attract small bits of leaves and straw.

The attractive properties of lodestone and amber baffled early philosophers and scientists. Aristotle reports that Thales of Miletus (640-548 B.C.) attributed the attractive properties of lodestone to ". . . a soul since it moves iron." Thales proposed a similar explanation for the behavior of amber.

Plutarch (46-120 A.D.) had a different explanation for amber's attractive properties. Rubbing it supposedly opened pores that allowed entrapped vapors to escape. Air, rushing in to fill the pores, pulled along with it nearby particles of dust and bits of straw. Amber is somewhat porous, and does have a distinct pine odor when the friction of rubbing produces heat, but the true explanation for its attractive powers is, of course, static electricity. Similarly, the attractive ability of lodestone lies in its inherent permanent magnetism.

Both lodestone and amber played fundamental roles in early electrical discoveries. The attractive properties of amber led to the investigation of static electricity and the eventual development of friction-operated electrostatic generators. The development of the first electromechanical machines can be traced to the eventual true understanding and exploitation of the properties of lodestone.

Lodestone and amber have also left us an important linguistic legacy. Because it was discovered in Greece's region of Magnesia, lodestones were called *Magnetis lithos* (stone of Magnesia), from which our word *magnet* was derived.

Amber's contribution is just as important. The Greek word for amber is *elektron*. In 1600, William Bilber published a book on magnetism in which he coined the term *electricia* to describe all substances which possess attractive properties like those of amber. In 1646, Sir Thomas Browne used for the first time the word *electricity*.

Microcomputer Update. An important trend in single-chip microcomputers is the incorporation of on-chip analog-to-digital (A/D) conversion. This permits the processing of analog data by a digital microcomputer without the need for an external A/D converter.

One of the latest microcomputers to incorporate on-chip A/D conversion is Motorola's MC6805R2. The architecture of this 8-bit, n-channel MOS chip makes it compatible with the 6800-microprocessor instruction set. It includes a clock, processor, 2048 bytes of user-programmable ROM, 64 bytes of RAM and a four-channel, eight-bit A/D converter.

Figure 1 is the block diagram of its A/D converter. The circuit uses a successive-approximation technique and requires 30 machine cycles per conversion. One of four analog signals can be routed to the converter circuit's comparator through a 4-channel analog multiplexer. The three lowest order bits in the A/D Control Register (CS0, CS1 and CS2) determine which input is selected according to the following coding format:

Input Selected	Control-Register Status		
	CS2	CS1	CS0
AN0	0	0	0
AN1	0	0	1
AN2	0	1	0
AN3	0	1	1

Other bit patterns in the Control Register control various other operations.

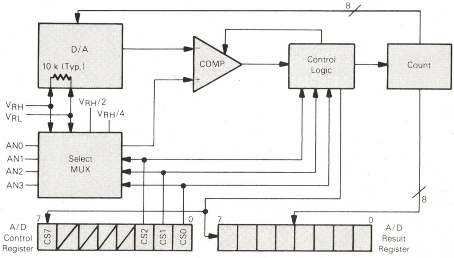

Fig. 1. Motorola's MC6805R 28-bit microcomputer with on-chip A/D converter.

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The advance information about the MC6805R2 that I received from Motorola did not include pricing data. For more information and a 26-page data booklet, write to Motorola Semiconductor Products, 3501 Ed Bluestein Blvd., Austin, TX 78721.

More on Magnetic Bubbles. Continuing last month's discussion, the general consensus is that bubble devices will eventually replace tape and flexible and rigid magnetic disks in many applications, but that prices will remain high until high-volume production starts.

A new bubble-memory module from Texas Instruments will give you a good idea how expensive these high-capacity memories with no moving parts currently happen to be. The module, designated the TM990/210L, can be supplied with two, four or six 92K-bit TIB0203 bubble memories for the storage of 23K, 46K or 69K bytes, respectively. This new module has a greater operating temperature range (0° to 70°C) than its predecessor, the TM990/210. It includes all necessary support circuitry and is bus-compatible with TI's TM990 series of microcomputer modules. Cost in single-unit quantities for the 23K-byte module is $1,160! The 46K-byte and 69K-byte modules cost $1,715 and $2,060, respectively, in single-unit quantities.

TI also sells the TM990/431 TIBUG software package, an interactive monitor for loading, debugging and executing programs for the TM990 microcomputer, which uses the TM990/210 bubble memory. The TIBUG software is available in the form of two TMS2716 EPROMS for $200.

If you want to know more about the TM990/210 bubble-memory module and the TIBUG software package (and if you can afford them!), write to Texas Instruments at Box 225012, M/S 308, Dallas, TX 75265.

Bubble memories are also available from Intel, Rockwell International and National Semiconductor. Intel's latest entry is the iSBC 254, a board that holds up to four one-megabit 7110 bubble-memory chips and their required control chips. The fully loaded 512,000-byte version is currently available for $6,300. According to Intel, the price will fall to $4,200 in several months. For more information, write to Intel Memory Systems, 1302 N. Mathilda, Sunnyvale, CA 94086.

Rockwell International sells a full line of bubble-memory boards having storage capacities of 32K, 64K, 128K and 256K bytes. A unique feature of these boards is that control and support functions are provided by a single-chip microcomputer. Watch for more products and peripherals using microcomputers in support roles. This technique is called *distributed processing*. Later this year, Rockwell will introduce a 256K-byte version of this board. For more information, write to Rockwell International's Electronic Devices Division, 3310 Miraloma Avenue, Anaheim, CA 92803.

National Semiconductor, like TI and Intel, is a major manufacturer of conventional memory chips. It will soon announce the availability of its BLC9081 board that contains eight one-megabit NBM2011 bubble memories and gives a full megabyte of storage capacity. For more information, write to National Semiconductor, 2900 Semiconductor Drive, Santa Clara, CA 95051. ◇

TI's magnetic-bubble data terminal being used by a sports reporter.

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AMATEUR RADIO

By Karl Thurber

The Morse Code: Alive and Kicking

CONTINUOUS wave (CW) or Morse code is the mode of transmission that gave radio communications its start. It's true that more sophisticated communications modes—RTTY, SSB, FM and TV—have come of age and supplanted CW to a large extent. However, CW communications still has a special place in ham radio, and it's far from a dying art. Because CW is an excellent training ground for those who want to get involved in radio communications, the FCC requires prospective Novice amateurs to demonstrate Morse-code proficiency at a speed of five words per minute (wpm) to qualify for a license. Furthermore, the Commission grants only CW operating privileges to Novice-class licensees to ensure that they get a healthy dose of CW communications before they upgrade.

Many amateurs with licenses that grant phone privileges do not abandon CW completely because they know it's hands-down the best communications medium when radio propagation is poor or interference (QRM) is heavy. There is nothing like CW for "cutting through the ether" and as a backup for RTTY and SSB circuits, especially under emergency conditions. Many hams thoroughly enjoy CW as an art unto itself. They wouldn't trade in their keys for a mike *for anything*!

It might be well to point out here that International Morse code, the proper name for the code amateurs use today, is sometimes called Continental code because it was first used on European wire telegraphy circuits, well before wireless communications was invented. International Morse code is often confused with American Morse code, which is significantly different and is largely obsolete.

CW Today. What causes this devotion to CW? To some extent, it's nostalgia, plain and simple. It's *fun* to communicate with another ham using techniques similar to those used by land-line telegraphers more than 100 years ago. More importantly, CW is enjoying newfound popularity because of recent technological developments and products embodying them that have made sending and receiving it pleasurable, relaxing and rewarding as never before.

Some of these new products include electronic, programmable-memory keyers and smooth-acting, dual-lever paddle assemblies; mechanically sophisticated semiautomatic keys ("bugs"); highly selective, solid-state audio filters; automatic, microprocessor-based CW-generating and -decoding equipment; and even specially designed, narrow-bandwidth speakers intended specifically for CW reception.

Accordingly, a contemporary CW station's transmitting gear will consist of a precision "iambic" (squeeze) paddle that allows even the neophyte to send code rapidly and accurately with maximum comfort and minimum fatigue. The paddle controls a programmable, solid-state keyer, one that not only generates machine-perfect CW but also has the capability to accept, store and then transmit on command any of several messages. The really sophisticated CW shack sports one of the new microprocessor-controlled Morse-generating keyboards or home-computer interface units that enables the user to send code *automatically* merely by typing out the message on a feather-touch keyboard.

The state-of-the-art CW station's receiver or transceiver is equipped with a sharp i-f crystal or mechanical filter. The station is also likely to have an external audio filter that allows the operator to tune out all stations except the desired one within its very narrow

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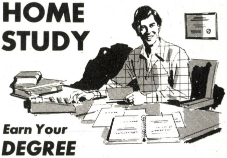

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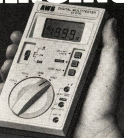

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passband. It is also equipped with a comfortable pair of high-quality headphones for use when listening through the speaker would not allow those weak DX signals to be heard. A specially designed, acoustically resonant CW speaker is also likely to be standard equipment. The station might also have a CW "processor" that regenerates the received code signal and keys an internal audio oscillator. This allows code reception almost completely free of interference, static or fading.

The receiving station will likely contain a digital Morse decoding unit that enables CW and RTTY as well to be decoded and displayed on a terminal for truly effortless copy. More modestly appointed stations (and some SWL listening posts) have relatively inexpensive code readers that print out received Morse on moving LED displays that are reminiscent of outdoor news and advertising displays.

Using CW. If you're new to ham radio, you'll need to increase your operating speed to 13 wpm to upgrade to the General class license. To do this, you will have to study and practice CW operating techniques. One of the best sources of information on how to work effectively using CW is the American Radio League's publications *Operating an Amateur Radio Station* and *Ham Radio Operating Guide*. Ameco, *73* magazine, and others also publish useful CW operating aids and guides.

You'll also have to get on-the-air experience, taking care to acquire only *good* operating habits. Regular listening to the daily code practice sessions broadcast by ARRL headquarters station W1AW is also a good way to help build code proficiency. This is especially true because the code sent is letter-perfect and is therefore excellent for code practice. The League's *QST* magazine lists the operating schedule of W1AW.

Joining an on-the-air net—either a "for-fun" group or a serious, message-handling net—is a fast way to increase code speed. These nets (many of them operate at slow speeds) can be found by scanning the 80- and 40-meter CW bands, including the Novice segments, in the early evening hours.

If you're fortunate enough to own an automatic CW-decoding microprocessor or CW reader, you can use it to back yourself up on your manual copying, and might even be able to get it to send you random-character code practice! However, it's usually best to steer clear of such devices, as well as fancy paddles, "bugs", and keyers until you have mastered ordinary, straight-key operation at speeds up to 10 wpm.

It's likely that CW will continue to prosper as a valuable means of radio communications, one that can be most enjoyable and that gets going when the going gets rough. So get the rust off your fist and the lead off your wrist, and limber up for some good, old-fashioned code work with a new twist. Who says CW isn't fun? ◇

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4:00-5:00 a.m.	0900-1000	R. Andorra	C	15026 (varies) (Sun.)
4:00-5:30 a.m.	0900-1030	R. Australia	B	15115
4:00-6:00 a.m.	0900-1100	AFRTS	A	11805, 9700, 9530, 9590, 6030
4:15-6:00 a.m.	0915-1100	BBC	C	17790, 17695, 15070, (21660 Sat. & Sun.)
4:30-5:15 a.m.	0930-1015	V. of the Malayan Revolution	C	15790, 11830
4:30-5:30 a.m.	0930-1030	V. of Germany	C	17780, 11850
4:45-7:15 a.m.	0945-1215	R. New Zealand	C	6105
5:00-5:15 a.m.	1000-1015	UN Radio	A	15250, 11090-LSB† 9565, (Sat.)
5:00-5:30 a.m.	1000-1030	R. Japan	B	9505
5:00-5:30 a.m.	1000-1030	V. of Vietnam	C	12033, 10010
5:00-6:00 a.m.	1000-1100	R. Korea	C	11725, 9570, 9870, 15575
5:00-fade out	1000-	R. Australia	B	6045, 5995
5:00-8:00 a.m.	1000-1300	R. Moscow (via Cuba)	B	9600, 600 (5045 -1100)
5:00-11:02 a.m.	1000-1602	ABC, Perth	B	9610, 6140
5:20-5:30 a.m.	1020-1030	V. of Guatemala	B	6180, 640 (time varies widely)
5:30-6:30 a.m.	1030-1130	Sri Lanka Br. Corp.	C	17850, 15120, 11835 (not all Eng.)
5:30-7:00 a.m.	1030-1200	V. of Asia, Taiwan	D	5980 (Sun. 1030-1040) (time varies)
5:55-6:55 a.m.	1055-1155	R. Thailand	C	11905, 9655
6:00-6:15 a.m.	1100-1115	R. Japan	B	9505
6:00-6:30 a.m.	1100-1130	V. of Vietnam	C	12035, 10010
6:00-6:30 a.m.	1100-1130	R. Mogadishu	D	9585
6:00-6:56 a.m.	1100-1156	R. RSA	C	25790, 21535
6:00-7:00 a.m.	1100-1200	V. of Nigeria	C	15119, 17800
6:00-7:00 a.m.	1100-1200	AFRTS	A	6030
6:00-7:30 a.m.	1100-1230	TWR-Bonaire	A	11815 or 15255
6:00-7:50 a.m.	1100-1250	R. Pyongyang	C	9977
6:00-8:00 a.m.	1100-1300	R. Australia	A	9580
6:00-8:30 a.m.	1100-1330	BBC	A-B	25650, 21710, 21660, 21550, 11775, 11750, 9740, 9510, 6195
6:00-9:00 a.m.	1100-1400	4VEH, Haiti	C	11835, 9770
6:00-10:00 a.m.	1100-1500	VOA	B	11715, 9565
6:00-11:00 a.m.	1100-1600	AFRTS	A	15430, 15330, 11805, 9700
6:15-6:30 a.m.	1115-1130	Vatican R.	C	21485, 17840 (not Sun.)
6:28-9:00 a.m.	1128-1400	CBC Northern Service	B-C	9625, 6065 (not all Eng.) (one hour earlier from Apr. 26)
6:30-6:55 a.m.	1130-1155	R. Nacional, Angola	D	11955, 9535 (Mon.-Fri.)
7:00-7:15 a.m.	1200-1215	R. Japan	B	9505
7:00-7:15 a.m.	1200-1215	V. of Kampuchean People	C	11938, 9694 (vary)
7:00-7:20 a.m.	1200-1220	Vatican R.	B	21485 17840 (not Sun.)
7:00-7:30 a.m.	1200-1230	Kol Israel	C	25640, 17612.5, 21675
7:00-7:30 a.m.	1200-1230	R. Finland	B	15400, (one hour later in March)
7:00-7:30 a.m.	1200-1230	R. Norway	C	21730, 25730, (Sun.)
7:00-7:30 a.m.	1200-1230	R. Tashkent	C	11785, 9540, 15460
7:00-7:45 a.m.	1200-1245	V. of Germany	B	21600, 17875, 17765, 15410
7:00-7:55 a.m.	1200-1255	R. Peking	B	15520 or 11945
7:00-8:00 a.m.	1200-1300	V. of Turkey	D	15185, 9560
7:00-8:00 a.m.	1200-1300	HCJB, Ecuador	A	26020, 15115, 11740
7:00-10:00 a.m.	1200-1500	R. Moscow World Service	B	17810, 15150, 7370
7:20-7:50 a.m.	1220-1250	R. Ulan Bator, Mongolia	C	11825, 6383 or 4850 or 7235† (not Sun.)
7:30-7:55 a.m.	1230-1255	Austrian R.	B	21655
7:30-7:55 a.m.	1230-1255	R. Tirana	D	11965 or 11960, 9515
7:30-8:00 a.m.	1230-1300	R. Sweden	C	21690
7:30-8:00 a.m.	1230-1300	BBC (English by radio)	C	21695
7:30-8:00 a.m.	1230-1300	R. Bangladesh	C	21770 or 21670. 15285
7:30-8:30 a.m.	1230-1330	TWR, Bonaire	A	15255 (Sat.; Sun.-1415)
7:30-8:30 a.m.	1230-1330	R. Korea	C	11830, 7550
7:30-8:30 a.m.	1230-1330	R. Finland	B	15400 (Sun.) (one hour later in March)
7:30-8:30 a.m.	1230-1330	R. Maldives	D	4754
7:30-10:51 a.m.	1230-1551	WYFR, Family Radio	A	21615, 17845 (Sun. only)
7:35-7:45 a.m.	1235-1245	V. of Greece	C	21455, 17830, 11730 (Mon.-Fri.)
8:00-8:15 a.m.	1300-1315	R. Japan	B	9505
8:00-8:20 a.m.	1300-1320	R. Canada International	A	17860, 15540, 11955, 9575 (Mon.-Fri.) (one hour earlier from Apr. 27)
8:00-8:30 a.m.	1300-1330	R. Bucharest	C	17850, 15250, 11940
8:00-8:45 a.m.	1300-1345	R. Berlin International	C	21540, 21465, 17700
8:00-9:00 a.m.	1300-1400	R. Australia	C	11705, 9770, 6080
8:00-9:30 a.m.	1300-1430	HCJB, Ecuador	A	26020, 17890, 15115, 11740
8:00-10:57 a.m.	1300-1557	R. RSA	B	25790, 21535, 15220
8:00-12:00 a.m.	1300-1700	WYFR, Family Radio	A	11830 (Sun. 1230-)
8:15-8:45 a.m.	1315-1345	Swiss R. International	B	21570, 21520
8:30-9:00 a.m.	1330-1400	R. Finland	B	21475, 15400 (one hour later in March)
8:30-9:00 a.m.	1330-1400	NYAB, Bhutan	D	4692 (Wed. & Fri. irreg.)
8:30-9:20 a.m.	1330-1420	R. Nederland	C	17605
8:30-9:30 a.m.	1330-1430	V. of Turkey	C	15125
8:30-9:30 a.m.	1330-1430	V. of Vietnam	C	10010
8:30-10:00 a.m.	1330-1500	All India R.	C	15335, 11810
8:30-11:00 a.m.	1330-1600	BBC	B-C	25650, 21710, 21660, 21550, 21470, 15400 (from 1430), 15070
8:30 a.m.-fade	1330-	R. Australia	B	6060

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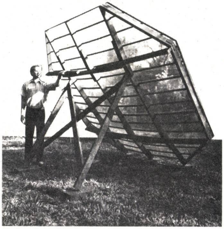

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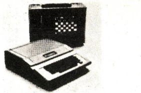
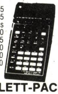
8:30 a.m.-5:00 p.m.	1330-2200	R. Moscow World Service (via Cuba)	B	11840 or 11860
8:35-9:05 a.m.	1335-1405	BRT, Belgium	B	21525 (Mon.-Fri.)
8:57-11:55 a.m.	1357-1655	V. of Philippines	D	9578 (Sun.-1555) (not all English)
9:00-9:30 a.m.	1400-1430	R. Japan	B	9505
9:00-9:30 a.m.	1400-1430	R. Sweden	B	21615
9:00-9:30 a.m.	1400-1430	R. Norway	B	15175, 21730 (Sun. only)
9:00-9:30 a.m.	1400-1430	V. Rev. Party, N. Korea	D	4557, 4109
9:00-9:30 a.m.	1400-1430	R. Tashkent	C	11785, 9540, 15460
9:00-10:00 a.m.	1400-1500	V. of Indonesia	C	15200, 11715
9:00-12:00 a.m.	1400-1700	CBC Southern Service	A	17820, 11955 (Sun.) (one hour earlier from Apr. 26)
9:00-12:30 a.m.	1400-1730	R. Australia	C	17795, 9770
9:00 a.m.-6:00 p.m.	1400-2300	CBC Northern Service	B-C	11720, 9625 (not all English) (from 1300 as of Apr. 26)
9:30-10:00 a.m.	1430-1500	KTWR, Guam	B	9510†
9:30-10:25 a.m.	1430-1525	R. Nederland	B	21480, 11735
9:30-11:00 a.m.	1430-1600	HCJB, Ecuador	A	26020, 17890, 15115
9:30-11:00 a.m.	1430-1600	Burma Br. Ser.	D	5985, 5040
9:30 a.m.-5:00 p.m.	1430-2200	UN Radio	A	21670, 15410 (when in session)
9:35-10:20 a.m.	1435-1520	R. Nepal	D	3425 or 7105 or 9589
9:50-10:35 a.m.	1450-1535	V. of the Malayan Revolution	C	15790, 11830
10:00-10:15 a.m.	1500-1515	R. Japan	C	9505
10:00-10;30 a.m.	1500-1530	V. of Asia, Taiwan	C	5980
10:00-11:00 a.m.	1500-1600	V. of Rev. Ethiopia	D	9560
10:00-11:00 a.m.	1500-1600	BBC	B	17830, 15260 (Sat, Sun)
10:00-11:00 a.m.	1500-1600	R. Moscow	B	15150
10:00-12:30 a.m.	1500-1730	BSHKJ, Jordan	D	9560
10:30-11:00 a.m.	1530-1600	R. Afghanistan	D	4775 or 6230
10:30-11:00 a.m.	1530-1600	R. Yugoslavia	C	15300, 15240
10:30-11:00 a.m.	1530-1600	Swiss R. International	B	21570
10:30-11:30 a.m.	1530-1630	V. of Vietnam	C	15012, 10040
10:35-10:45 a.m.	1535-1545	V. of Greece	C	21555, 17830, 11730 (Mon.-Fri.)
10:45-11:00 a.m.	1545-1600	R. Canada International	A	(17820 Mon.-Sat.), 21695, 15325
11:00-11:15 a.m.	1600-1615	R. Japan	C	9505
11:00-11:15 a.m.	1600-1615	Vatican R.	C	17730
11:00-11:15 a.m.	1600-1615	R. Pakistan	C	21755, 21605, 21486, 17910, 17660†
11:00-11:30 a.m.	1600-1630	R. Norway	B	21730, 17795, 15175 (Sun. only)
11:00-11:30 a.m.	1600-1630	R. Portugal	C	21530 (not Sun.)
11:00-12:00 a.m.	1600-1700	R. Korea	B	11830, 9720
11:00 a.m.-12:09 p.m.	1600-1709	BBC	B	21710, 17830, 15260
11:00 a.m.-1:00 p.m.	1600-1800	AFRTS	A	15430, 15330, 11805
11:00 a.m.-4:00 p.m.	1600-2100	R. Moscow World Service	B	11860 †
11:00 a.m.-6:00 p.m.	1600-2300	VOA	A	26040, 21660, 21485, 17870, (15250 from 1900) 15445, (15410 to 2200)
11:05-11:55 a.m.	1605-1655	R. France International	B	21620, 21580, 21515, 17860 (one hour later in March)
11:10-11:55 a.m.	1610-1655	BRT, Belgium	C	21525† (one hour later in March)
11:30 a.m.-1:00 p.m.	1630-1800	R. Nacional Angola	D	11955, 9535, 7245 (Sun. from 1600)
-11:30 a.m.	-1630	R. Singapore	C	11940, 9530, 5052, 5010 (fade-in time varies)
11:45-12:00 a.m.	1645-1700	R. Canada International	A	17820 (Mon.-Sat.), 15325, 21695
11:45-12:45 p.m.	1645-1745	R. Pakistan	C	15485 or 9460 and 9425, 11675†
12:00-12:15 p.m.	1700-1715	R. Japan	C	9505
12:00-12:30 p.m.	1700-1730	HCJB, Ecuador	B	26020, 21480, 17790†
12:00-1:00 p.m.	1700-1800	WYFR, Family Radio	A	21615, 17845, 17735, 15440, 11830
12:00-3:00 p.m.	1700-2000	4VEH, Haiti	C	11835, 9770 (Sun.)
12:00-5:00 p.m.	1700-2200	VOA	B	17785, 15205, 11760, 9760, (15140 from 1830)
12:09-12:45 p.m.	1709-1745	BBC	B	17830, 15260
12:15-1:05 p.m.	1715-1805	V. of Germany	C	21600
12:45-3:00 p.m.	1745-2000	BBC	C	17705, 15400, 15070, 12095 (11820 from 1800)
12:45-5:30 p.m.	1745-2230	All India R.	C	11620
1:00-1:15 p.m.	1800-1815	R. Japan	B	9505
1:00-1:30 p.m.	1800-1830	R. Canada International	A	17820, 15260 (Sat. & Sun. - 1900)
1:00-1:30 p.m.	1800-1830	R. Norway	C	17840, 17715 (Sun. only)
1:00-2:00 p.m.	1800-1900	V. of Vietnam	C	10040
1:00-2:00 p.m.	1800-1900	WYFR, Family Radio	A	21615, 17735
1:00-2:00 p.m.	1800-1900	V. of Nigeria	C	15119, 15185, 17800
1:00-3:00 p.m.	1800-2000	R. Australia	C	21630, 17795
1:00-4:00 p.m.	1800-2100	R. Kuwait	C	11650
1:00-5:00 p.m.	1800-2200	B.S.K. Saudi Arabia	C	11854
1:00-5:00 p.m.	1800-2200	AFRTS	A	15430, 15330, 15345
1:15-1:45 p.m.	1815-1845	Swiss R. International	C	21570, 17830, 17850
1:15-2:15 p.m.	1815-1915	R. Bangladesh	D	15100, 11765 (both vary)†
1:30-1:35 p.m.	1830-1835	UN Radio	A	19505-SSB, 15410, 11960, 17740, 15305 (Mon.-Fri.)
1:30-1:57 p.m.	1830-1857	Austrian Radio	C	15560 (Sun. from 1805)
1:30-2:00 p.m.	1830-1900	V. of Revolution, Guinea	C	15313 (varies) 9650 (Mon. Wed. and Fri.) (irregular)
1:30-2:30 p.m.	1830-1930	V. of Iran	D	9022
1:45-2:15 p.m.	1845-1915	Sri Lanka Br. Corp.	C	17850, 15120, 15115, 11870
2:00-2:10 p.m.	1900-1910	R. Tahiti	C	15170, 11825 (exc. Sun)
2:00-2:15 p.m.	1900-1915	R. Japan	B	15270
2:00-2:30 p.m.	1900-1930	R. Canada International	A	21695, 17875, 15325 (Sat. & Sun. -2000)
			A	17820, 15260 (Mon.-Fri.)
2:00-2:30 p.m.	1900-1930	R. Afghanistan	C	15079 (varies) or 17742†
2:00-3:00 p.m.	1900-2000	HCJB, Ecuador	C	26020, 21480, 17790†, 15295†
2:00-3:00 p.m.	1900-2000	WYFR, Family Radio	A	21615, 15130, 11830
2:00-4:00 p.m.	1900-2100	R. Nacional, Brazil	C	17810, 15125
2:35-5:00 p.m.	1935-2200	TIFC, Costa Rica	C	9645 (Sun.)
2:45-4:15 p.m.	1945-2115	R. Free Grenada	C	15104 (time varies and irregular)
3:00-3:15 p.m.	2000-2015	R. Japan	B	15270
3:00-3:30 p.m.	2000-2030	R. Norway	C	11895, 11860 (Sun.)
3:00-3:30 p.m.	2000-2030	R. Canada International	A	21695, 17875, 17820, 15325 (Mon.-Fri.)
3:00-3:30 p.m.	2000-2030	Kol Israel	C	17685, 15105, 9815, 9425, 9009

3:00-4:00 p.m.	2000-2100	WYFR, Family Radio	A	21615, 21525, 15130, 11830
3:00-4:15 p.m.	2000-2115	BBC	A	15260, 15070, 11750
3:00-12:00 p.m.	2000-0500	R. Moscow (via Cuba)	C	600
3:10-4:40 p.m.	2010-2140	R. Habana Cuba	A	15155 or 11920
3:30-4:20 p.m.	2030-2120	R. Nederland	B	21685, 17695, 17605, 15220, 9715
3:30-4:30 p.m.	2030-2130	V. of Vietnam	C	15012, 10040†
3:30-4:30 p.m.	2030-2130	V. Turkey	C	9725†
3:45-5:30 p.m.	2045-2230	All India R.	C	15110
3:50-4:00 p.m.	2050-2100	R. Free Europe	C	17835, 15420 or 15290, 11825 † (Fri., one hour later in March)
3:50-4:40 p.m.	2050-2140	R. Habana Cuba	C	17750, 9770
4:00-4:15 p.m.	2100-2115	R. Japan	B	15270
4:00-4:30 p.m.	2100-2130	R. Algiers	C	21725 or 21635, 15307 (varies)† (one hour earlier from May)
4:00-4:50 p.m.	2100-2150	R. RSA	B	17775, 15155, 11900
4:00-5:00 p.m.	2100-2200	V. of Nigeria	C	15185, 15119, 17800
4:00-5:00 p.m.	2100-2200	R. Moscow	C	21530, 15455
4:00-5:00 p.m.	2100-2200	WYFR, Family Radio	A	21615, 21525, 15170
4:15-6:00 p.m.	2115-2300	BBC	A	15260, 15070, 9510, 6175
4:15-7:30 p.m.	2115-2430	R. Free Grenada	B	15045 (time varies)
4:30-5:00 p.m.	2130-2200	R. Canada International	A	17820, 17875, 15325, 15150, 11945
4:30-5:00 p.m.	2130-2200	KGEI, San Francisco	C	15280
4:30-5:00 p.m.	2130-2200	HCJB Ecuador	C	26020, 21480, 17790, 15295†
4:30-5:00 p.m.	2130-2200	R. Sofia	B	15135, 11860†
4:30-5:30 p.m.	2130-2230	R. Baghdad	C	9745
4:40-5:40 p.m.	2140-2240	V. of Free China	C	17890, 15270, 11825
4:45-5:15 p.m.	2145-2215	Swiss R. International	B	21585
4:50-12:30 p.m.	2150-0530	R. New Zealand	C	17860
5:00-5:15 p.m.	2200-2215	R. Japan	B	17755, (via Portugal 11790†)
5:00-5:30 p.m.	2200-2230	R. Argentina	C	11710 (Mon.-Sat.)
5:00-5:30 p.m.	2200-2230	R. Norway	C	15345, 15135 (Sun. only)
5:00-6:00 p.m.	2200-2300	WYFR, Family Radio	A	21525, 15130, 11855, 9535
5:00-6:00 p.m.	2200-2300	CBC Radio	A	17875, 15325, 11780 (Mon.-Fri.) (from 2100 as of Apr. 27)
5:00-6:00 p.m.	2200-2300	R. Moscow	B	21530, 15455, 11860
5:00-6:00 p.m.	2200-2300	V. of Turkey	B	9725, 7215†
5:00-6:00 p.m.	2200-2300	R. Clarin, Dom. Rep.	B	11700 (Sat. & Sun.; irregular)
5:00-7:00 p.m.	2200-2400	AFRTS	A	25615, 21570, 15430, 15330, 15345
5:00-11:30 p.m.	2200-0430	VOA	A	21460, 17740, (26000 – 2400), (17820 -0100)
5:15-5:30 p.m.	2215-2230	R. Yugoslavia	C	9620
5:30-6:00 p.m.	2230-2300	Kol Israel	A	15584, 11638, 9815
5:30-6:25 p.m.	2230-2325	R. Mexico	B	15430 (Sun. time varies)
5:45-6:00 p.m.	2245-2300	SODRE, Uruguay	C	11885, 9515 (time varies)
5:45-6:00 p.m.	2245-2300	UN Radio	A	15225, 11830 (Fri.)
6:00-6:30 p.m.	2300-2330	R. Japan	C	17755
6:00-6:30 p.m.	2300-2330	R. Sweden	B	11705, 9695
6:00-6:30 p.m.	2300-2330	R. Vilnius	B	15405, 11735†
6:00-7:00 p.m.	2300-2400	4VEH, Haiti	B	11835, 9770
6:00-7:00 p.m.	2300-2400	WYFR, Family Radio	A	21525
6:00-7:00 p.m.	2300-2400	R. Mexico	B	15430 (Thurs. time varies)
6:00-7:30 p.m.	2300-2430	BBC	A	15260, 15070, 11910, 9590, 9580, 9410, 7325, 6175, 6120, 5975
6:00-7:50 p.m.	2300-2450	R. Pyongyang	C	9977
6:00-8:00 p.m.	2300-0100	CBC Southern Service	A	9755, 5960 (Sat. - 2330 and Sun.-2400) (one hour earlier from Apr. 26)
6:00-8:00 p.m.	2300-0200	R. Moscow	A	21530, 17720, 15455, 15140, 12050, 12010, 11960, 11860, 11780, 11735, 9765, 9710, 9685, 9610
6:00 p.m.1:07 a.m.	2300-0607	CBC Northern Service	B-C	9625, 6195 (not all English) (until 0507 as of Apr. 27)
6:25-7:00 p.m.	2325-2400	SODRE, Uruguay	C	11885, 9515 (time varies)
6:30-7:00 p.m.	2330-2400	HCJB Ecuador	B	26020, 15350
6:30-7:00 p.m.	2330-2400	V. of Vietnam	C	12035, 10080,10040, 10010
6:45-7:45 p.m.	2345-2445	R. Japan	C	17825, 15270
7:00-7:15 p.m.	0000-0015	R. Japan	C	17755
7:00-7:25 p.m.	0000-0025	R. Tirana	B	9750, 7065
7:00-7:30 p.m.	0000-0030	R. Mexico	C	17765, 15430, 11770 (Sat.; freq. time changes)
7:00-7:30 p.m.	0000-0030	R. Canada International	A	9755, 5960 (from Apr. 27)
7:00-7:30 p.m.	0000-0030	Kol Israel	A	15584, 11638, 9815
7:00-7:30 p.m.	0000-0030	R. Norway	C	11870, 9590 (Mon. only)
7:00-7:45 p.m.	0000-0045	R. Berlin International	C	11970, 9730 (one hour later in March)
7:00-7:55 p.m.	0000-0055	R. Peking	B	17855, 17680, 15125
7:00-8:00 p.m.	0000-0100	WYFR, Family Radio	A	17845, 5985
7:00-8:00 p.m.	0000-0100	R. Sofia	B	9705 or 15330
7:00-8:00 p.m.	0000-0100	AFRTS	A	25615, 21570, 15330, 15345, 11790
7:00-9:00 p.m.	0000-0200	R. Luxembourg	C	6090 (Time varies)
7:00-9:00 p.m.	0000-0200	VOA	A	17730, 15205, 11740, 9650, 6130, 5995
7:00-12:00 p.m.	0000-0500	R. Moscow (via Cuba)	A	9600 or 6115
7:00-12:00 p.m.	0000-0500	FEBC Philippines	C	17810
7:00 p.m.-4:00 a.m.	0000-0900	UN Radio	A	6055 (when in session)
7:05-8:55 p.m.	0005-0155	Spanish Foreign R.	B	11880, 9630
7:15-8:00 p.m.	0015-0100	BRT, Belgium	C	15385 or 11695; 15175
7:25-7:40 p.m.	0025-0040	SODRE, Uruguay	C	11885, 9515 (time varies)
7:30-8:00 p.m.	0030-0100	R. Prague	C	6055
7:30-8:00 p.m.	0030-0100	R. Kiev	B	17870, 15240, 15100, 11790, 11770
7:30-8:00 p.m.	0030-0100	R. Budapest	B	17710, 15220, 11910, 9835, 9585 (Wed. and Fri.) (one hour later in March)
7:30-8:00 p.m.	0030-0100	La Cruz del Sur, Bolivia	D	4875 (Mon. only)
7:30-9:00 p.m.	0030-0200	HCJB, Ecuador	A	15155
7:30-9:30 p.m.	0030-0230	BBC	A	15260, 11835, 11750, 9580, 9410, 7325, 6175, 6120, 5975
7:35-9:30 p.m.	0035-0230	HCJB, Ecuador	B	26020, 15355, 9745
7:55-8:35 p.m.	0055-0135	TWR-Bonaire	B	11745†
8:00-8:15 p.m	0100-0115	R. Japan	C	17755





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CIRCLE NO. 19 ON FREE INFORMATION CARD

8:00-8:15 p.m.	0100-0115	Vatican R.	B	11845, 9605, 6015
8:00-8:20 p.m.	0100-0120	RAI, Italy	B	11800, 9575
8:00-8:25 p.m.	0100-0125	Kol Israel	A	15584, 11638, 9815
8:00-8:30 p.m.	0100-0130	R. Argentina	B	11710 (not Mon.)
8:00-8:00-8:30 p.m.	0100--130	R. Mexico	B	15430 (Sun., time varies)
8:00-8:30 p.m.	0100-0130	R. Budapest	B	17710, 15220, 11910, 9835, 9585 (not Mon.) (one hour later in March)
8:00-8:30 p.m.	0100-0130	R. Canada International	A	17820, 9755, 5960
8:00-8:55 p.m.	0100-0155	R. Prague	B	11990, 9740, 9540, 7345, 5930
8:00-8:55 p.m.	0100-0155	R. Peking	B	17855, 17680, 15125
8:00-9:00 p.m.	0100-0200	V. of Free China	C	17890, 15345, 11825
8:00-9:00 p.m.	0100-0200	AFRTS	A	25615, 21570, 11790, 6030
8:00-9:00 p.m.	0100-0200	WYFR, Family Radio	B	11710
8:00-10:30 p.m.	0100-0330	R. Australia	B	21740, 17795
8:00-11:50 p.m.	0100-0450	R. Habana Cuba	B	11930, 11725
8:20 p.m.-12:10 a.m.	0120-0510	R. Belize	C	3285, 834
8:20-8:50 p.m.	0120-0150	V. of Germany	A	15105, 11865, 9565, 9545, 6145, 6100, 6085, 6040
8:30-8:45 p.m.	0130-0145	V. of Greece	B	11730, 9655, 9515 (not Sun.)
8:30-8:55 p.m.	0130-0155	Austrian Radio	B	9770, 5945
8:30-8:55 p.m.	0130-0155	R. Tirana	B	9750, 7120
8:30-9:15 p.m.	0130-0215	R. Berlin International	C	11970, 9730 (one hour later in March)
8:30-9:30 p.m.	0130-0230	R. Japan	C	21640, 17825, 17725, 15235
8:45-9:15 p.m.	0145-0215	Swiss R. International	A	15305, 11715, 9725, 6135
9:00-9:15 p.m.	0200-0215	R. Japan	C	17755
9:00-9:25 p.m.	0200-0225	Kol Israel	A	15584, 11638, 9815
9:00-9:30 p.m.	0200-0230	R. Canada International	A	11940, 9605, 5960
9:00-9:30 p.m.	0200-0230	R. Norway	B	11850, 9685, 9590 (Mon. only)
9:00-9:30 p.m.	0200-0230	R. Budapest	B	17710, 15220, 11910, 9835, 9585, 6000†
9:00-9:40 p.m.	0200-0240	R. Polonia	C	15120, 11815, 9525, 7270, 7145, 6135, 6095 (length varies)
9:00-9:50 p.m.	0200-0250	R. RSA	B	15325, 11900, 9585
9:00-9:55 p.m.	0200-0255	R. Bucharest	C	11940, 11840, 11735, 9690, 9570, 5990
9:00-9:55 p.m.	0200-0255	R. Peking	B	17855, 17680, 15120
9:00-10:00 p.m.	0200-0300	WYFR, Family Radio	A	11710, 5985
9:00-10:00 p.m.	0200-0300	R. Nacional, Brazil	A	15290, 17830
9:00-10:30 p.m.	0200-0330	R. Cairo	B	12050, 9475
9:00-11:00 p.m.	0200-0400	R. Moscow	A	17720, 15455, 15140, 12050, 12010, 11960, 11860, 11780, 9765, 9710, 9700, 9685, 9610, (9580 from 0330), 9530
9:00-11:00 p.m.	0200-0400	VOA	A	15205, 9650, 5995
9:00-11:30 p.m.	0200-0430	AFRTS	A	21570, 17765, 11790, 6030
9:30-9:45 p.m.	0230-0245	R. Pakistan	C	21590, 17835, 21745†
9:30-9:45 p.m.	0230-0245	UN Radio	A	15240, 6035, 15685 -SSB 10869-SSB (Sat.)
9:30-9:55 p.m.	0230-0255	R. Tirana	B	9750, 7120
9:30-10:00 p.m.	0230-0300	R. Lebanon	C	15170 or 11820† (time varies)
9:30-10:00 p.m.	0230-0300	R. Finland	C	11735, 9645 or 15400† (one hour earlier in March)
9:30-10:00 p.m.	0230-0300	R. Sweden	C	11705, 9695
9:30-10:15 p.m.	0230-0315	R. Berlin International	B	11975, 11890, 11840 (one hour later in March)
9:30-10:25 p.m.	0230-0325	R. Nederland	A	9590, 6165
9:30-10:30 p.m.	0230-0330	R. Korea	C	15575, 11810
9:30-10:30 p.m.	0230-0330	BBC	A	11750, 9580, 9410, 7325, 6175, 6120, 5975
9:30-12:00 p.m.	0230-0500	HCJB, Ecuador	A	15155, 9745, 11915, 26020
10:00-10:15 p.m.	0300-0315	R. Japan	C	17755
10:00-10:15 p.m.	0300-0315	R. Budapest	B	17710, 15220, 11910, 9835, 9585, 6000† (Wed. & Fri.; Mon. -0430) (one hour later in March)
10:00-10:25 p.m.	0300-0325	R. Polonia	C	15120, 11815, 9525, 7270, 7145, 6135, 6095 (length varies)
10:00-10:30 p.m.	0300-0330	R. Canada International	A	11940, 11845, 9605, 9535, 5960
10:00-10:30 p.m.	0300-0330	R. Portugal	B	11925, 6185 or 15125†
10:00-10:30 p.m.	0300-0330	R. Kiev	B	17870, 15100, 15240, 11790, 9665
10:00-10:30 p.m.	0300-0330	R. Australia	C	15260 (Fri.)
10:00-10:50 p.m.	0300-0350	V. of Free China	C	17890, 15270, 11825
10:00-10:55 p.m.	0300-0355	R. Prague	B	11990, 9740, 9540, 7345, 5930
10:00-10:55 p.m.	0300-0355	R. Peking	B	17855, 17680, 15120
10:00-11:00 p.m.	0300-0400	TIFC Costa Rica	C	9645, 5055, (Mon. 0235-0435)
10:00-11:00 p.m.	0300-0400	R. Baghdad	D	11935
10:00-11:15 p.m.	0300-0415	R. Uganda	B	15325 (irregular)
10:00-11:26 p.m.	0300-0426	R. RSA	B	15220, 11900, 9585, 7270
10:00-11:30 p.m.	0300-0430	R. Cultural, Guatemala	B	3300 (Mon. 0030–)
10:00 p.m.-1:00 a.m.	0300-0600	HP.VC, Honduras	B	4820
10:00 p.m.-1:00 a.m.	0300-0600	WYFR, Family Radio	A	11810, 5985
10:00 p.m.-2:30 a.m.	0300-0730	VOA	A	15330, 15245, 9670, 6040, 6035, 5995
10:25 p.m.-fade	0325-	R. One, Zimbabwe	C	3396 (exc. Sun.)
10:30-10:45 p.m.	0330-0345	U.A.E. Radio Dubai	B	21700, 11755, 9505
10:30-10:55 p.m.	0330-0355	R. Tirana	B	7300, 6200
10:30-10:55 p.m.	0330-0355	Austrian Radio	C	9770, 5945
10:30-11:00 p.m.	0330-0400	R. Australia	B	21680, 17890, 17870, 17795, 17725
10:30-11:45 p.m.	0330-0445	BBC	A	9410, 6175, 6120, 5975
10:30-12:00 p.m.	0330-0500	AWR Guatemala	C	5980†
10:30 p.m.-1:00 a.m.	0330-0600	R. Habana Cuba	A	11760, 11725
10:40-10:47 p.m.	0340-0347	V. of Greece	B	11730, 9650, 9515 (not Sun.)
10:50-11:10 p.m.	0350-0410	RAI, Italy	C	11905, 17795, 15330
10:51-10:58 p.m.	0351-0358	V. of Yerevan	C	17870, 15405, 15100
11:00-11:15 p.m.	0400-0415	R. Japan	C	17755
11:00-11:30 p.m.	0400-0430	R. Bucharest	C	11940, 11840, 11735, 9690, 9570, 5990

11:00-11:30 p.m.	0400-0430	R. Canada International	A	11845, 9535, 5960
11:00-11:30 p.m.	0400-0430	R. Norway	C	11895, 6185 (Mon. only)
11:00-11:30 p.m.	0400-0430	R. Mozambique	C	4855, 3265
11:00-11:55 p.m.	0400-0455	R. Peking	B	17680, 15230, 15120
11:00-12:00 p.m.	0400-0500	R. Australia	B	21680, 21650, 21525, 17890, 17870, 17795, 17755, 17725, 15320, 15240, 15160
11:00 p.m.-1.00 a.m.	0400-0600	R. Moscow World Service	B	17880, 15460, 9800, 9610,
11:00 p.m.-3:00 a.m.	0400-0800	R. Moscow	B	15470, 15455, 12050, 12010, 9580
11:05-11:50 p.m.	0405-0450	FEBA, Seychelles	C	11850†
11:30-11:55 p.m.	0430-0455	Austrian R.	B	12015
11:30-12:00 p.m.	0430-0500	Swiss R. International	B	11715, 9725
11:30-12:00 p.m.	0430-0500	R. Sofia	B	9765 or 9530 or 11750†
11:30 p.m.-2:00 a.m.	0430-0700	AFRTS	A	11790, 6030
11:45-12:00 p.m.	0445-0500	Vatican Radio	C	6210 or 6190 (one hour later in March)
11:45 p.m.12:45 a.m.	0445-0545	BBC	A	9510, 6175, 5975, 9410
11:55 p.m.-1:00 a.m.	0455-0600	V. of Nigeria	C	7255
12:00-12:15 a.m.	0500-0515	Kol Israel	B	15105, 11960, 11638, 9009†
12:00-12:15 a.m.	0500-0515	R. Japan	C	15270
12:00-12:30 a.m.	0500-0530	R. Portugal	B	9575 or 11925, 6185
12:00-1:00 a.m.	0500-0600	R. Australia	C	21680, 17890, 17870, 17725, 15240, 15160
12:00-2:00 a.m.	0500-0700	HCJB, Ecuador	B	9745, 6095, 11915, 26020
12:00-3:00 a.m.	0500-0800	R. Kuwait	C	21545
12:00-5:00 a.m.	0500-1000	V. of Cuba	B	550 or 600
12:15-1:15 a.m.	0515-0615	Spanish Foreign R.	B	11880, 9630
12:22-12:30 a.m.	0522-0530	UN Radio	A	9540, 6055 (Tue.-Sat.)
12:30-12:40 p.m.	0530-0540	R. Garoua, Cameroon	C	5010
12:30-12:50 a.m.	0530-0550	V. of Germany	A	11905, 9650, 9545, 6100, 5960
12:30-fade	0530-	R. Ghana	C	3366, 4915
12:30-1:25 a.m.	0530-0625	R. Nederland	B	9715, 6165
12:40-7:15 a.m.	0540-1215	R. New Zealand	C	11945
12:45-1:00 a.m.	0545-0600	UN Radio	A	9540, 6055 (Tue.-Sat.)
12:45-2:30 a.m.	0545-0730	BBC	B	15070, 11955, 11860, 9640, 9510, 9410, 7150, 6175
1:00-1:15 a.m.	0600-0615	R. Japan	C	15270
1:00-1:30 a.m.	0600-0630	V. of Germany	C	17875, 15275, 11905, 11765, 9700
1:00-1:30 a.m.	0600-0630	R. Norway	B	9645, 15175 (Mon. only)
1:00-1:30 a.m.	0600-0630	R. Australia	C	21680, 21525, 17870, 17795, 17755, 17725, 15240, 15160
1:00-3:00 a.m.	0600-0800	V. of Nigeria	C	15185, 15119, 17800
1:15-1:30 a.m.	0615-0630	R. Canada International	B	17860, 15265, 11960, 11825, 9760, 9590, 6140, 6045 (Mon-Fri)
1:25-3:00 a.m.	0625-0800	TWR, Monte Carlo	B	9495† (one hour later in March)
1:25-3:55 a.m.	0625-0855	V. of Malaysia	C	15295, 12350, 9750
1:30-2:00 a.m.	0630-0700	R. Australia	B	21680, 17870, 17725, 15240, 15115
1:30-2:00 a.m.	0630-0700	Radio Polonia	B	9675, 7270
1:30-2:30 a.m.	0630-0730	R. RSA	B	21535, 17780, 15220
1:30-3:00 a.m.	0630-0800	R. Habana Cuba	A	9525
1:45-2:00 a.m.	0645-0700	R. Canada International	B	17860, 15265, 11960, 11825, 9760, 9590, 6140, 6045 (Mon-Fri)
1:45-2:00 a.m.	0645-0700	UN Radio	A	15125, 11735 (Sat.)
1:57-4:55 a.m.	0657-0955	V. of Philippines	C	9578 (not all English)
2:00-2:15 a.m.	0700-0715	R. Japan	C	15270, (15130† via Portugal)
2:00-2:30 a.m.	0700-0730	Swiss Radio Int.	C	21520, 15305, 9535, 6165
2:00-3:00 a.m.	0700-0800	Xandir Malta	C	9670 (Sat.) (irregular)
2:00-3:00 a.m.	0700-0800	ELWA, Liberia	C	11830
2:00-3:00 a.m.	0700-0800	V. of Vietnam	C	7512, 9840, 6383
2:00-3:30 a.m.	0700-0830	HCJB, Ecuador	C	11835, 9760†
2:00-4:00 a.m.	0700-0900	R. Australia	B	21680, 17725, 15115, 11740, 9570
2:00-5:30 a.m.	0700-1030	HCJB, Ecuador	C	11900, 9745, 6130
2:07-2:15 a.m.	0707-0715	UN Radio	A	17815, 15195 (Sat.)
2:30-3:25 a.m.	0730-0825	R. Nederland	B	9770, 9715
2:30-4:00 a.m.	0730-0900	BBC	B	15070, 11955, 9640, 9510
2:30-6:30 a.m.	0730-1130	Solomon Isl. Broadcasting	C	9545 or 5020 (Not all Eng.)
2:30-9:00 a.m.	0730-1400	NBC, Dapua, N. Guinea	C	4890, 3925 (not all Eng.)
2:30-9:02 a.m.	0730-1402	ABC Melbourne	C	9680
2:37-2:45 a.m.	0737-0745	UN Radio	A	17815, 15195 (Sat.)
2:45-4:30 a.m.	0745-0930	KTWR, Guam	B	11840
2:55 a.m.-fade	0755-	Action Radio, Guyana	C	5950
2:55-3:05 a.m.	0755-0805	V. of Guatemala	B	6180, 640 (time varies)
3:00-3:15 a.m.	0800-0815	R. Japan	B	9505
3:00-3:30 a.m.	0800-0830	R. Norway	C	9590 (Sun.)
3:00-315 a.m.	0800-0815	UN Radio	A	17860, 15235, 15125, 11735 (Sat.)
3:00-4:00 a.m.	0800-0900	R. Korea	B	15575, 11810, 9870
3:00-9:00 a.m.	0800-1400	R. East Coast Commercial	D	11578† (Sat.)
3:30-3:35 a.m.	0830-0835	UN Radio	A	15250, 10385, 9565 (Sat.)
3:30-3:45 a.m.	0830-0845	R. Vanuatu	C	7260, 3945
3:30-4:25 a.m.	0830-0925	R. Nederland	B	9715
3:30-5:00 a.m.	0830-1000	FEBC, Philippines	C	11890 or 11765
24 Hours	24 Hours	CFRX, Toronto	C	6070

Explanatory Notes.

1. Times in first column are EST/CDT. For AST add 1 hour, CST/MDT, subtract 1 hour, MST/PDT, subtract 2 hours, PST, subtract 3 hours. Days of week are in GMT.
2. Quality. A—strong signal and very reliable reception. B—regular reception. C—occasional reception under favorable conditions. D—rarely audible. These ratings are for locations in the central USA. European and African stations are in general, more reliably received in eastern North America. Asian and Pacific stations are more reliably received in western North America. North American stations are received well except in areas too close to the transmitter site.
3. The information in this listing is correct to press time. However, frequencies and schedules are constantly changing. Listen to "DX Digest" on R. Canada International for late changes, Saturday at 2130; Sunday at 1930; GMT Mondays at 0100 (from April 27, 0060 and 0400.
4. R.—Radio; V.—Voice

† = frequent changes

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CIRCLE NO. 44 ON FREE INFORMATION CARD

PROJECT OF THE MONTH

By Forrest M. Mims

A Liquid-Level Indicator for the Blind

HAVE you ever wondered how a blind person knows when to stop pouring liquid into a glass or cup? The blind people I have known usually insert a finger into the cup to the desired depth. Then they pour until they feel the liquid with their fingertip. Unfortunately, this procedure can cause discomfort if the liquid is hot, and can be socially awkward if a blind host is serving sighted guests.

The simple circuit shown in Fig. 1 will help your blind friend or relative pour liquids with relative ease and without having to touch the liquid. The circuit is inexpensive to build and uses an LM3090 LED-flasher chip as an audio oscillator. The circuit emits a tone whose frequency in part depends on the value of *C1*. When the probe leads, which parallel *C1*, are bridged by a low-to-moderate resistance, the frequency of oscillation suddenly increases. Such a probe, shown in Fig. 2, can be connected to the audio generator by a suitable length of flexible two-conductor wire.

With the value of *C1* as shown, the frequency of oscillation is about 1.6 kHz. When the probe clips were attached to the rim of a plastic cup and tap water was poured into the cup to the level of the probes, the frequency of the tone increased to approximately 3 kHz. The frequency change that your circuit exhibits might differ from these values. Different beverages have various values of conductivity and can produce different frequency changes. In any event, you will hear a distinct tone change when the liquid bridges the probe tips.

If you build this circuit for a blind friend, house it in a small plastic box. Make sure the battery holder is readily accessible, as the cells must be easily replaced by one who cannot see.

Be sure to place a raised marker at the positive end of the battery holder to indicate the correct battery orientation. A drop of paint or glue will do. Your blind friend should have little difficulty replacing the cells if *you* can do it blindfolded.

Incidentally, the liquid-level indicator can be designed to emit a tone *only* when liquid bridges the probes. I prefer the two-tone approach because the blind user always knows when the unit has been switched on and therefore will remember to turn it off when he has finished using it.

Going Further. You can add a volume control or alter the frequencies that the circuit generates or both. The former is easily accomplished by reducing the value of *R1* to 47 ohms and inserting a 1-kΩ potentiometer in series with *R1*. To alter the tone frequencies, try different values for *C1*. Increasing the value of *C1* will lower the frequency and reducing the capacitance will raise it.

The entire circuit should be self-contained and complete with battery and miniature acoustic transducer. The LM3909 can even be powered by a single 1.5-volt silver-oxide cell of the type used to power digital watches. This will allow you to assemble a miniature unit. The audio output could be provided by a miniature earphone salvaged from a discarded hearing aid. Alternatively, you can use a midget transistor-radio earphone. ◇

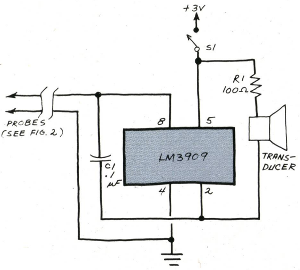

Fig. 1. Schematic diagram for a simple liquid level indicator circuit for the blind.

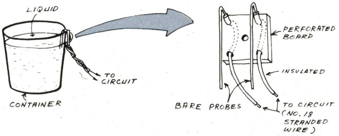

Fig. 2. How to assemble a liquid level indicator probe to fit over the edge of a container.

OPERATION ASSIST

If you need information on outdated or rare equipment—a schematic, parts list, etc.—another reader might be able to assist. Simply send a postcard to Operation Assist, POPULAR ELECTRONICS, *1 Park Ave., New York, NY 10016. For those who can help readers, please respond directly to them. They'll appreciate it. (Only those items regarding equipment not available from normal sources are published.)*

Howard radio model A-450. Need service manual. Stephan Selby, 7555 Decatur Road, Lot 38, Ft. Wayne, IN 46816.

Supro model S6422TR guitar amplifier. Need schematic diagram. Ed Arnold, 316 Division St., Jackson, TN 38301.

Telefunken 2550 stereo. Need schematic diagram and service information. T.F. Lindstrom, Star Route 1, Box 119AA, Bonners Ferry, ID 83805.

Kaar Engineering Corp. model TR237B radio telephone. Need manual, schematic or information on 12.6V power supply. Paul Swanson, Rt. 1, Box 78, Mason, WI 54856.

Sears model 4168 silvertone color TV. Need technical manual #94-4341.Mr. H. Singer, Box 148, Jamesburg, NJ 08831.

Accurate Instrument Co. model 257 TV. Need operations manual and instructions for testing picture tubes. Larry R. Cook, 362 East South St., Richland Center, WI 53581.

Philco model TRR-76BK tape recorder. Need motor, part #325-0076-58 or parts source. Anthony Estatico, Jr., 610 Fourth Ave., Pelham, NY 10803

Paco model M-40 VOM. Need schematic and service manual. Bayir Sokak, 40/2, Tesvikiye, Istanbul, Turkey.

Hallicrafters model WR-600 receiver. Need operation and service manual. Robert Anderson, Area Fac Engineer, Yongan, APO San Francisco, CA 96301.

Imperial Electronics model R390-A/URR receiver. Need manual or operating instructions. M. Bloom, 311 Weymouth St, Dix Hills, NY 11746.

Webcor Regent model ED-2950 tape recorder and **Metz** stereophonic multiband console. Need schematic diagrams for both. T. Crawford, 1121 28th St., N., Fargo, ND 58102.

Crown model 5HC-47F tape recorder. Need schematic. Rodney Ring, 1690 Merchant St., S. Parks, NV 89431.

Simpson 260, series 5, VOM. Need operations manual. James Humphrey, 1006 E. 28th St., Los Angeles, CA 90011.

Hallicrafters model S-120 receiver and **Knight** star roamer. Need manuals, schematics and service information. L.R. Oliver, 4046 Twining, Riverside, CA 92509.

Cubic model V-46 APS digital voltmeter. Need schematic and operation manual. J.L. Bartha, 1539 W. Holtz Ave., Addison, IL 60101.

Army surplus RCV-XMTR RT-175A/PRC-9. Need schematic, manual or any information available on the battery for this unit. Dan Kuiper, 10562 Brewer Dr., Northglenn, CO 80234.

Zenith model 1005 radio. Need service manual, schematic and owner's manual. Stephen Marano, 290 Zimmerman Blvd., Kenmore, NY 14223.

Siemens 560WO radio. Need schematic, service and assembly manuals. Andrew Rhodd, Rosemount, Linstead, St. Catherine, Jamaica, W.I.

Hy-Gain model 628 vhf-uhf monitor scanner. Need schematic. N.J. Ward, 2811 Schumacher, Mishowaka, IN 46544.

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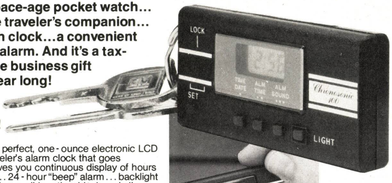

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	1N4007	1000v	1A	.15
	1N4148	75v	10mA	.05
	1N4733	5.1v	1 W Zener	.25
	1N4749	24v	"	.25
	1N753A	6.2v	500 mW Zener	.25
	1N758A	10v	"	.25
	1N759A	12v	"	.25
	1N5243	13v	"	.25
	1N5244B	14v	"	.25
	1N5245B	15v	"	.25
	1N5349	12v	3W Zener	.25

SOCKETS/BRIDGES

QTY					
	8-pin	pcb	.20	ww	.40
	14-pin	pcb	.25	ww	.60
	16-pin	pcb	.30	ww	.70
	18-pin	pcb	.35	ww	.95
	20-pin	pcb	.45	ww	1.05
	22-pin	pcb	.50	ww	1.15
	24-pin	pcb	.55	ww	1.25
	28-pin	pcb	.60	ww	1.45
	40-pin	pcb	.70	ww	1.75
	Molex pins	.01		To-3 Sockets	.35
	2 Amp Bridge			200-prv	1.35
	25 Amp Bridge			200-prv	2.25

TRANSISTORS, LEDS, etc.

QTY			
	2N2222M (Metal)	.25	(2N2222 Plastic .20)
	2N2222A	NPN	.35
	2N2907A	PNP	.35
	2N3906	PNP (Plastic)	.25
	2N3904	NPN (Plastic)	.25
	2N3054	NPN 4A 90v	.60
	2N3055	NPN 15A 60v	.75
	TIP125	PNP Darlington	1.95
	LED	Green Red Clear Yellow	.19
	DL747	7 seg ⅝" High com-anode	2.25
	DL 728B	doub 7 seg 5" com-cathode	2.50
	MA6740	doub 7 seg 5" com-cathode	2.50
	MAN72	7 seg com-anode (Red)	1.50
	MAN3630	7 seg com-anode ±1	1.00
	MAN82A	7 seg com-anode (Yellow)	1.50
	MAN74	7 seg com-cathode (Red)	1.50
	FND359	7 seg com-cathode (Red)	1.50

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QTY			QTY			QTY			QTY		
	7400	.35		7493	.60		74H11	.45		74LS74	.95
	7401	.25		7494	.75		74H15	.45		74LS75	.95
	7402	.35		7495	.60		74H20	.35		74LS76	.90
	7403	.35		7496	.55		74H21	.35		74LS86	.95
	7404	.45		74100	2.75		74H22	.40		74LS90	1.85
	7405	.35		74107	.55		74H30	.40		74LS93	1.00
	7406	.55		74121	.55		74H40	.45		74LS107	.90
	7407	.65		74122	.55		74H50	.40		74LS109	1.00
	7408	.50		74123	.70		74H51	.40		74LS123	1.20
	7409	.35		74125	.75		74H52	.40		74LS138	1.00
	7410	.35		74126	.75		74H53	.45		74LS151	1.00
	7411	.35		74132	.75		74H55	.45		74LS153	1.15
	7412	.35		74141	.90		74H72	.45		74LS154	2.00
	7413	.45		74145	1.35		74H74	1.50		74LS157	1.75
	7414	.65		74150	1.15		74H101	.95		74LS160	1.65
	7416	.35		74151	.95		74H103	.55		74LS161	1.50
	7417	.40		74153	.95		74L00	.80		74LS164	1.90
	7420	.45		74154	1.40		74L02	.75		74LS193	2.00
	7426	.35		74156	.70		74L03	.35		74LS195	2.00
	7427	.40		74157	.95		74L04	.90		74LS196	2.50
	7430	.40		74161	1.50		74L10	.30		74LS244	1.50
	7432	.65		74163	1.50		74L20	.45		74LS245	3.50
	7437	.55		74164	1.50		74L30	.55		74LS253	1.95
	7438	.70		74165	1.10		74L47	1.95		74LS298	1.50
	7440	.40		74166	1.10		74L51	.65		74LS367	1.50
	7441	.95		74175	.95		74L55	.85		74LS368	1.95
	7442	.95		74176	1.15		74L72	.65		74LS373	1.50
	7443	.75		74177	1.10		74L73	.70		74S00	.70
	7444	.75		74180	1.10		74L74	1.95		74S02	.90
	7445	.75		74181	2.25		74L75	1.05		74S03	.45
	7446	.90		74182	.75		74L85	3.00		74S04	.70
	7447	1.50		74190	1.25		74L93	2.95		74S05	.65
	7448	1.50		74191	1.25		74L123	2.95		74S08	1.80
	7450	.35		74192	1.50		74LS00	.50		74S10	.95
	7451	.25		74193	1.50		74LS01	.60		74S11	.75
	7453	.25		74194	.95		74LS02	.50		74S20	.75
	7454	.35		74195	.95		74LS03	.60		74S22	.75
	7460	.40		74196	1.75		74LS04	.60		74S40	.70
	7470	.35		74197	.95		74LS05	.60		74S50	.70
	7472	.40		74198	1.50		74LS08	.60		74S51	.75
	7473	.40		74221	1.50		74LS09	.60		74S64	.35
	7474	.45		74298	2.50		74LS10	.60		74S74	1.50
	7475	.45		74367	1.15		74LS11	.60		74S86	1.25
	7476	.95		75107A	1.50		74LS20	.65		74S112	1.90
	7480	.60		75451	.85		74LS21	.50		74S114	.85
	7481	.95		75452	.85		74LS22	.45		74S133	.85
	7482	.95		75491	1.50		74LS27	.60		74S140	.95
	7483	.75		75492	1.50		74LS32	.80		74S151	1.50
	7485	.95		74H00	.50		74LS37	.60		74S153	2.25
	7486	.55		74H01	.50		74LS38	.95		74S157	2.95
	7489	1.95		74H04	.90		74LS40	.70		74S158	1.75
	7490	.75		74H05	.55		74LS42	.75		74S194	1.75
	7491	.60		74H08	.90		74LS47	1.95		74S196	2.00
	7492	.50		74H10	.45		74LS51	.95		74S257(8123)	1.95
										74S287	5.95
										8131	2.75

C MOS

QTY			QTY			QTY			QTY		
	4000	.40		4019	1.15		4041	1.15		4081	.55
	4001	.35		4020	.95		4042	.65		4082	.60
	4002	.35		4021	.75		4043	.90		4093	.90
	4006	1.50		4022	.75		4044	.90		4098	2.25
	4007	.30		4023	.35		4046	1.50		4507	.95
	4008	.75		4024	.95		4047	2.50		4511	1.50
	4009	.40		4025	.35		4048	2.50		4512	1.25
	4010	.35		4026	1.95		4049	.50		4515	2.95
	4011	.65		4027	.65		4050	.65		4519	.85
	4012	.25		4028	.95		4052	.75		4522	1.10
	4013	.65		4029	1.50		4053	1.50		4526	.95
	4014	.75		4030	.45		4066	.75		4528	1.50
	4015	.75		4033	1.50		4069/74C04	.45		4529	.95
	4016	.55		4034	2.75		4070	.60		MC14409	14.50
	4017	1.50		4035	.95		4071	.40		MC14419	4.85
	4018	.95		4040	1.50		4072	.50		74C151	2.50

I^2L, LINEARS, REGULATORS, etc.

QTY			QTY			QTY		
	MCT2(E)	1.25		LM320K24	1.65		LM373	3.95
	8038	4.50		LM320T5(7905)	1.65		LM377	2.95
	LM201	2.00		LM320T12	1.65		78L05	.95
	LM301	.95		LM320T15	1.65		78L12	.95
	LM308	1.25		LM323K	7.95		78L15	.95
	LM309H	1.50		LM324	1.00		78M05	.95
	LM309(340K-5)	1.50		LM337T	2.25		LM380(8-14Pin) 386N	1.19
	LM310	.85		LM339	.95		LM709(8-14Pin)	.75
	LM311(8-14Pin)	1.50		7805(340T5)	1.50		LM711	.45
	LM317T	2.25		LM340T12	1.50		LM723	.75
	LM318N	2.15		LM340T15	1.50		LM725	3.95
	LM320H6	.89		LM340T18	1.50		LM739	1.50
	LM320H15	.89		LM340T24	1.50		LM741(8-14)	.75
	LM320H24	.89		LM340K12	1.50		LM747	1.25
	LM320K5	1.65		LM340K15	1.50		LM1307	1.75
	LM320K12	1.65		LM340K18	1.50		LM1458	.65
	LM320K15	1.65		LM340K24	1.50		LM3900	.75
							LM3909	1.50
							NE555	.50
							NE556	1.00
							NE565	1.50
							NE566	1.75
							NE567	1.50
							TA7205	4.95
							76477	2.95
							95H90	9.95
							TL081CP	.75

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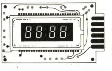
CIRCLE NO. 30 ON FREE INFORMATION CARD

National Semiconductor Clock Modules



12VDC
AUTOMOTIVE/
INSTRUMENT
CLOCK

APPLICATIONS:
- In-dash autoclocks
- After-market auto/ RV clocks
- Aircraft-marine clks.
- 12VDC oper. instru.
- Portable/battery powered instrumnts.

Features: Bright 0.3" green display. Internal crystal time-base. ± 0.5 sec./day accur. Auto. display brightness control logic. Display color filterable to blue, blue-green, green & yellow. Complete—just add switches and lens.

MA1003 Module $16.95

MA1023	.7" Low Cost Digital LED Clock Module	8.95
MA1026	.7" Dig. LED Alarm Clock/Thermometer	18.95
MA5036	.3" Low Cost Digital LED Clock/Timer	6.95
MA1002	.5" LED Display Dig. Clock & Xformer	9.95

National Semiconductor

RAM SALE

MM5290N-4 (MK4116/UPD416) . . **$4.95 each**
16K DYNAMIC RAM (250NS)
(8 EACH $39.95) (100 EACH $450.00/lot)

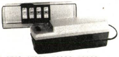
MM5290J-2 (MK4116/UPD416) . . **$6.95 each**
16K DYNAMIC RAM (150NS)
(8 EACH $49.95) (100 EACH $550.00/lot)

MM5298J-3A .... **$3.25 each**
8K DYNAMIC RAM (LOW HALF OF MM5290J) 200NS
(8 EACH $23.95) (100 EACH $250.00/lot)

MM2114-3 .... **$5.95 each**
4K STATIC RAM (300NS)
(8 EACH $43.95) (100 EACH $450.00/lot)

MM2114L-3 .... **$6.25 each**
4K STATIC RAM (LOW POWER 300NS)
(8 EACH $44.95) (100 EACH $475.00/lot)

EPROM Erasing Lamp



- Erases 2708, 2716, 1702A, 5203Q, 5204Q, etc.
- Erases up to 4 chips within 20 minutes.
- Maintains constant exposure distance of one inch.
- Special conductive foam liner eliminates static build-up.
- Built-in safety lock to prevent UV exposure.
- Compact – only 7-5/8" x 2-7/8" x 2"
- Complete with holding tray for 4 chips.

UVS-11E $79.95

Jumbo 6-Digit Clock Kit

- Four .630"ht. and two .300"ht. common anode displays
- Uses MM5314 clock chip
- Switches for hours, minutes and hold functions
- Hours easily viewable to 30 feet
- Simulated walnut case
- 115VAC operation
- 12 or 24 hour operation
- Includes all components, case and wall transformer
- Size: 6¾" x 3-1/8" x 1¾"

JE747 .... $29.95

6-Digit Clock Kit

- Bright .300 ht. comm. cathode display
- Uses MM5314 clock chip
- Switches for hours, minutes and hold modes
- Hrs. easily viewable to 20 ft.
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hr. operation
- Incl. all components, case & wall transformer
- Size: 6¾" x 3-1/8" x 1¾"

JE701 .... $19.95

NEW! JE215 Adjustable Dual Power Supply

General Description: The JE215 is a Dual Power Supply with independent adjustable positive and negative output voltages. A separate adjustment for each of the supplies provides the user unlimited applications for IC current voltage requirements. The supply can also be used as a general all-purpose variable power supply.

FEATURES:
- Adjustable regulated power supplies, pos. and neg. 1.2VDC to 15VDC.
- Power Output (each supply): 5VDC @ 500mA, 10VDC @ 750mA, 12VDC @ 500mA, and 15VDC @ 175mA.
- Two, 3-terminal adj. IC regulators with thermal overload protection.
- Heat sink regulator cooling
- LED "on" indicator
- Printed Board Construction
- 120VAC input
- Size: 3-1/2"w x 5-1/16"L x 2"H

JE215 Adj. Dual Power Supply Kit (as shown) . . $24.95

(Picture not shown but similar in construction to above)
JE200 Reg. Power Supply Kit (5VDC, 1 amp) . . $14.95
JE205 Adapter Brd. (to JE200) ±5, ±9 & ±12V. $12.95
JE210 Var. Pwr. Sply. Kit, 5-15VDC, to 1.5amp. $19.95

MICROPROCESSOR COMPONENTS

8080A/8080A SUPPORT DEVICES

INS8080A	CPU	6.50
DP8212	8-Bit Input/Output	3.25
DP8214	Priority Interrupt Control	5.95
DP8216	Bi-Directional Bus Driver	3.49
DP8224	Clock Generator/Driver	3.95
DP8226	Bus Driver	3.49
DP8228	System Controller/Bus Driver	4.95
DP8238	System Controller	5.95
INS8243	I/O Expander for 48 Series	9.95
INS8250	Asynchronous Comm. Element	16.95
DP8251	Prog. Comm. I/O (USART)	7.95
DP8253	Prog. Interval Timer	14.95
DP8255	Prog. Peripheral I/O (PPI)	9.95
DP8257	Prog. DMA Control	19.95
DP8259	Prog. Interrupt Control	14.95
DP8275	Prog. CRT Controller	49.95
DP8279	Prog. Keyboard/Display Interface	19.95
DP8300	Octal Bus Receiver	6.95
DP8303	System Timing Element	6.95
DP8304	8-Bit Bi-Directional Receiver	3.95
DP8307	8-Bit Bi-Directional Receiver	3.95
DP8308	8-Bit Bi-Directional Receiver	3.95

6800/6800 SUPPORT DEVICES

MC6800	MPU	14.95
MC6802CP	MPU with Clock and RAM	19.95
MC6810API	128x8 Static RAM	4.95
MC6821	Peripheral Inter. Adapt (MC6820)	7.49
MC6828	Priority Interrupt Controller	10.95
MC6830L8	1024x8-Bit ROM (MC68A30-8)	14.95
MC6850	Asynchronous Comm. Adapter	6.95
MC6852	Synchronous Serial Data Adapter	6.95
MC6860	0-600bps Digital MODEM	10.95
MC6862	2400bps Modulator	12.95
MC6880A	Quad 3-State Bus. Trans. (MC8T26)	2.25

MICROPROCESSOR CHIPS

Z80 (780C)	CPU (MK3880N) (2MHz)	13.95
Z80A (780-1)	CPU (MK3880N-4) (4MHz)	15.95
CDP1802	CPU	19.95
2650	MPU	16.95
IDM2901ADC	CPU—4-Bit Slice (Com. Temp. Grade)	19.95
MCS6502	MPU w/Clock (65K Bytes Memory)	11.95
INS8035N-6	MPU—8-Bit (6MHz)	16.95
INS8039N-6	CPU—Sgl. Chip 8-Bit (128 bytes RAM)	19.95
INS8040N-6	CPU (256 Bytes RAM)	24.95
INS8070N	CPU—64 Bytes RAM	24.95
INS8073N	CPU w/Basic Micro Interpreter	29.95
P8085	CPU	19.95
INS8900	CPU—16-Bit	29.95
TMS9900JL	MPU—16-Bit	49.95

SHIFT REGISTERS

MM500H	Dual 25-Bit Dynamic	.50
MM503H	Dual 50-Bit Dynamic	.50
MM506H	Dual 100-Bit Static	.50
MM510H	Dual 64-Bit Accumulator	.50
MM1402	256-Bit Dynamic	3.95
MM5013	1024-Bit Dynamic/Accumulator	1.95
MM5016H	500/512-Bit Dynamic	.89
MM5034N	Octal 80-Bit	9.95
MM5035N	Octal 80-Bit	9.95
2504V (1404A)	1024-Bit Dynamic	3.95
2518N	Hex 32-Bit Static	4.95
2522V	Dual 132-Bit Static	2.95
2524V	512-Bit Dynamic	.99
2525V	1024-Bit Dynamic	2.95
2527V	Dual 256-Bit Static	2.95
2528V	Dual 250-Bit Static	4.00
2529V	Dual 240-Bit Static	4.00
2532N	Quad 80-Bit Static	2.95
3341PC	Fifo (Dual 80)	6.95

DATA ACQUISITION

AF100-1CN	Universal Active Filter 2.5%	5.95
AF121-1CJ	Touch Tone Low Pass Filter	19.95
AF122-1CJ	Touch Tone Low Pass Filter	19.95
LM308AH	Super Gain Op Amp	1.00
LM334Z	Constant Current Source	1.30
LM335Z	Temperature Transducer	1.40
LF356N	JFET Input Op Amp	1.10
LF398N	Sample & Hold Amplifiers	3.95
LM399H	Temp. Comp. Prec. Ref. (.5ppm/C°)	4.95
ADC0804LCN	8-Bit A/D Converter (1 LSB)	4.95
DAC0806LCN	8-Bit D/A Converter (0.78% Lin.)	2.25

DATA ACQUISITION (CONTINUED)

ADC0809CCN	8-Bit A/D Converter (8-Ch. Multi.)	5.25
ADC0817CCN	8-Bit A/D Converter (16-Ch. Multi.)	10.95
DAC1000LCN	10-Bit D/A Conv. Micro. Comp. (0.05%)	13.95
DAC1008LCN	10-Bit D/A Conv. Micro. Comp. (0.20%)	8.95
DAC1020LCN	10-Bit D/A Converter (0.05% Lin.)	8.49
DAC1022LCN	10-Bit D/A Converter (0.20% Lin.)	5.95
DAC1222LCN	12-Bit D/A Converter (0.20% Lin.)	9.95
CD4051N	8-Channel Multiplexer	1.19
AY-5-1013	30K BAUD UART	5.95

RAM'S

1101	256x1 Static	1.49
1103	1024x1 Dynamic	.99
2101 (8101)	256x4 Static	3.95
2102	1024x1 Static	1.75
21L02	1024x1 Static	1.95
2111 (8111)	256x4 Static	3.95
2112	256x4 Static MOS	4.95
2114	1024x4 Static 450ns	5.95
2114L	1024x4 Static 450ns Low Power	6.95
2114-3	1024x4 Static 300ns	7.49
2114L-3	1024x4 Static 300ns Low Power	7.95
2117	16,384x1 Dynamic 550ns (house marked)	4.95
4116 (UPD416)	16K Dynamic 250ns	4.95
MM2147J	4096x1 Fast 70ns	19.95
5101	256x4 Static	7.95
MM5261	1024x1 Dynamic Fully Decoded	.99
MM5262	2Kx1 Dynamic	.25
MM5280/2107	4096x1 Dynamic	4.95
MM5290J-2(4116)	16K Dynamic 150ns (UPD416)	6.95
MM5298J-3A	8K Dyn. 200ns (lower ½ of MM5290J)	4.95
7489	16x4 Static	1.75
UPD414/MK4027	4K Dynamic 16-pin	4.95
TMS4044-45NL	4K Static	14.95
TMS4045	1024x4 Static	14.95

PROMS/EPROMS

1702A	2K UV Erasable PROM	5.95
2708	8K EPROM	9.95
TMS2716	16K EPROM (-5V, +5V, +12V)	19.95
2716 Intel (2516) TI	16K EPROM (Single +5V)	17.95
2732 Intel (2532) TI	32K EPROM	49.95
2758	8K EPROM (450ns) (Single +5V)	7.95
5203	2048 PROM	14.95
82S23(74S188)	32x8 PROM (Open Collector)	4.95
82S115	4096 Bipolar PROM	19.95
82S123(74S288)	32x8 Tri-State Bipolar PROM	4.95
82S185	8K PROM	29.95

ROM'S

2513(2140)	Character Generator (Upper Case)	9.95
2513(3021)	Character Generator (Lower Case)	9.95
2516N	Character Generator	10.95
MM5230N	2048-Bit Read Only Memory	1.95

NMOS READ ONLY MEMORIES

MCM66710P	128x9x7 ASCII Shifted w/Greek	13.50
MCM66740P	128x9x7 Math Symbol & Pictures	13.50
MCM66750P	128x9x7 Alpha. Control Char. Gen.	13.50

MICROPROCESSOR MANUALS

M-Z80	User Manual	7.50
M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00

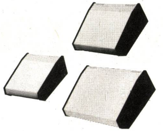
SPECIAL FUNCTION

DS0025CN	Dual MOS Clock Driver (5MZ)	3.50
DS0026CN	Dual MOS Clock Driver (5MZ)	1.95
INS1771N-1	Floppy Disc Controller	24.95
INS2651N	Communication Chip	19.95
MM58167N	Microprocessor Real Time Clock	8.95
MM58174N	Microprocessor Compatible Clock	11.95
COP402N	Microcontroller with 64-Digit RAM and Direct LED Drive	6.95
COP402MN	Microcontroller with 64-Digit RAM & Direct LED Drive w/N Buss Int.	7.49
COP470N	32-Seg. VAC Fluor. Driver (20-pin pkg.)	3.25

TELEPHONE/KEYBOARD CHIPS

AY-5-9100	Push Button Telephone Dialer	14.95
AY-5-9200	Repertory Dialer	14.95
AY-5-9500	CMOS Clock Generator	4.95
AY-5-2376	Keyboard Encoder (88 keys)	11.95
HD0165-5	Keyboard Encoder (16 keys)	7.95
74C922	Keyboard Encoder (16 keys)	5.49
74C923	Keyboard Encoder (20 keys)	5.75
MM53190N	Push Button Pulse Dialer	7.95
MM57499N	96/144-Key Serial Keyboard Encoder	8.95

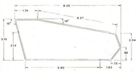
DESIGNERS' SERIES
Blank Desk-Top Electronic Enclosures



- High strength epoxy molded end pieces in mocha brown finish.
- Sliding rear/bottom panel for service and component accessibility.
- Top/bottom panels .080 thk alum. Alodine type 1200 finish (gold tint color) for best paint adhesion after modification.
- Vented top and bottom panels for cooling efficiency.
- Rigid construction provides unlimited applications.

CONSTRUCTION:

The "DTE" Blank Desk Top Electronic Enclosures are designed to blend and complement today's modern computer equipment and can be used in both industrial and home. The end pieces are precision molded with an internal slot (all around) to accept both top and bottom panels. The panels are then fastened to ¼" thick tabs inside the end pieces to provide maximum rigidity to the enclosure. For ease of equipment servicing, the rear/bottom panel slides back on slotted tracks while the rest of the enclosure remains intact. Different panel widths may be used while maintaining a common profile outline. The molded end pieces can also be painted to match any panel color scheme.



Enclosure Model No.	Panel Width	PRICE
DTE-8	8.00"	$29.95
DTE-11	10.65"	$32.95
DTE-14	14.00"	$34.95

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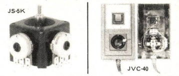


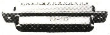
JS-5K	5K Linear Taper Pots	$5.25
JS-100K	100K Linear Taper Pots	$4.95
JVC-40	40K (2) Video Controller in case . . .	$5.95

AC and DC Wall Transformers

Ideal for use with clocks, games, power supplies or any other type of AC or DC application.

Part No.	Input	Output	Price
AC 250	117V/60Hz	12 VAC 250mA	$3.95
AC 500	117V/60Hz	12 VAC 500mA	$4.95
AC1000	117V/60Hz	12 VAC 1 amp	$5.95
AC1700	117V/60Hz	9 VAC 1.7 amp	$6.95
DV 9200	117V/60Hz	9 VDC 200mA	$3.25
DC 900	120V/60Hz	9 VDC 500mA	$3.95

CONNECTORS



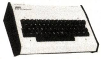
DB25P	D-Subminiature Plug	$2.95
DB25S	D-Subminiature Socket	$3.50
DB51226	Cover for DB25P/S	$1.75
22/44SE	P.C. Edge (22/44 Pin)	$2.95
UG88/U	BNC Plug	$1.79
UG89/U	BNC Jack	$3.79
UG175/U	UHF Adapter	$ .49
SO239	UHF Panel Recp.	$1.29
PL258	UHF Adapter	$1.60
PL259	UHF Plug	$1.60
UG260/U	BNC Plug	$1.79
UG1094/U	BNC Bulkhead Recp.	$1.29

TRS-80
16K Conversion Kit

Expand your 4K TRS-80 System to 16K.
Kit comes complete with:
★ 8 ea. MM5290 (UPD416/4116) 16K Dyn. Rams (*NS)
★ Documentation for Conversion

TRS-16K2 *150NS **$49.95**
TRS-16K4 *250NS **$39.95**

JE610 ASCII
Encoded Keyboard Kit



The JE610 ASCII Keyboard Kit can be interfaced into most any computer system. The kit comes complete with an industrial grade keyboard switch assembly (62-keys), IC's, sockets, connector, electronic components and a double-sided printed wiring board. The keyboard assembly requires +5V @ 150mA and –12V @ 10 mA for operation. Features: 60 keys generate the 126 characters, upper and lower case ASCII set. Fully buffered. Two user-define keys provided for custom applications. Caps lock for upper-case-only alpha characters. Utilizes a 2376 (40-pin) encoder read-only memory chip. Outputs directly compatible with TTL/DTL or MOS logic arrays. Easy interfacing with a 16-pin dip or 18-pin edge connector. Size: 3½"H x 14½"W x 8¾"D

JE610/DTE-AK (as pictured above) . . . **$124.95**

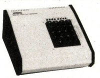
JE610 Kit 62-Key Keyboard, PC Board, & Components (no case). . . . . **$ 79.95**

K62 62-Key Keyboard (Keyboard only) . . . **$ 34.95**

DTE-AK (case only — 3¼"Hx11"Wx8¾"D) **$ 49.95**

JE600
Hexadecimal Encoder Kit

FULL 8-BIT
LATCHED OUTPUT
19-KEY KEYBOARD



The JE600 Encoder Keyboard Kit provides two separate hexadecimal digits produced from sequential key entries to allow direct programming for 8-bit microprocessor or 8-bit memory circuits. Three additional keys are provided for user operations with one having a bistable output available. The outputs are latched and monitored with 9 LED readouts. Also included is a key entry strobe. Features: Full 8-bit latched output for microprocessor use. Three user-define keys with one being bistable operation. Debounce circuit provided for all 19 keys. 9 LED readouts to verify entries. Easy interfacing with standard 16-pin IC connector. Only +5VDC required for operation. Size: 3½"H x 8¼"W x 8¾"D

JE600/DTE-HK (as pictured above) **$99.95**

JE600 Kit 19-Key Hexadec. Keyboard, PC Board & Cmpnts. (no case) . . **$59.95**

K19 19-Key Keyboard (Keyboard only) **$14.95**

DTE-HK (case only — 3½"Hx8¼"Wx8¾"D) **$44.95**

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INTEGRATED CIRCUITS

7400 TTL

7400N	.32
7401N	.32
7402N	.32
7403N	.32
7404N	.35
7405N	.35
7406N	.41
7407N	.41
7408N	.35
7409N	.37
7410N	.32
7411N	.35
7413N	.48
7414N	.85
7416N	.41
7417N	.41
7420N	.32
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7440N	.32
7442N	.73
7445N	.93
7446N	1.06
7447N	1.06
7448N	1.06
7450N	.32
7451N	.32
7453N	.32
7454N	.32
7460N	.35
7470N	.49
7472N	.49
7473N	.46
7474N	.46
7475N	.62
7476N	.46
7483N	.85
7485N	.95
7486N	.46
7489N	1.75
7490N	.53
7491N	.89
7492N	.60
7493N	.57
7495N	.71
7496N	.79
74107N	.46
74109N	.46
74121N	.55
74123N	.71
74125N	.64
74126N	.64
74132N	.82
74141N	1.19
74145N	.93
74147N	1.73
74148N	1.33
74150N	1.12
74151N	.73
74153N	.73
74154N	1.21
74155N	.79
74156N	.79
74157N	.73
74160N	.93
74161N	1.02
74162N	.93
74163N	.93
74164N	.98
74165N	1.15
74166N	1.26
74170N	1.87
74173N	1.35
74174N	.90
74175N	.84
74176N	.96
74177N	.96
74180N	1.00
74181N	2.00
74182N	1.10
74190N	1.01
74191N	1.01
74192N	1.03
74193N	.95
74194N	.93
74195N	.88
74196N	.91
74197N	.91
74198N	1.49
74199N	1.49
74251N	1.12
74365N	.80
74366N	.80
74367N	.80
74368N	.80

74LS00 LS TTL

74LS00N	.36
74LS01N	.36
74LS02N	.36
74LS03N	.36
74LS04N	.38
74LS05N	.38
74LS08N	.36
74LS09N	.38
74LS10N	.36
74LS11N	.38
74LS12N	.36
74LS13N	.59
74LS14N	1.25
74LS15N	.38
74LS20N	.36
74LS21N	.38
74LS22N	.36
74LS26N	.37
74LS27N	.36
74LS30N	.36
74LS32N	.41
74LS37N	.37
74LS38N	.37
74LS40N	.38
74LS42N	.85
74LS47N	1.08
74LS48N	1.08
74LS49N	1.18
74LS51N	.36
74LS54N	.36
74LS55N	.36
74LS73N	.49
74LS74N	.46
74LS75N	.59
74LS76N	.54
74LS78N	.49
74LS83N	1.08
74LS85N	1.28
74LS86N	.50
74LS90N	.73
74LS93N	.73
74LS107N	.46
74LS113N	.49
74LS114N	.49
74LS122N	.75
74LS123N	1.03
74LS125N	.64
74LS126N	.64
74LS132N	.93
74LS136N	.49
74LS138N	.84
74LS139N	.84
74LS151N	.77
74LS153N	.84
74LS154N	1.44
74LS155N	.91
74LS156N	.91
74LS157N	.77
74LS158N	.86
74LS160N	1.07
74LS161N	1.07
74LS162N	1.07
74LS163N	1.07
74LS164N	1.18
74LS168N	1.51
74LS169N	1.51
74L170N	1.84
74LS173N	1.34
74LS174N	1.22
74LS175N	.90
74LS190N	1.30
74LS191N	1.30
74LS192N	1.17
74LS193N	1.17
74LS196N	1.34
74LS197N	1.34
74LS221N	1.37
74LS247N	1.19
74LS248N	1.19
74LS249N	1.19
74LS253N	1.02
74LS257N	.89
74LS258N	.97
74LS266N	.50
74LS283N	1.03
74LS290N	1.12
74LS293N	1.12
74LS352N	1.30
74LS353N	1.44
74LS365N	.70
74LS366N	.70
74LS368N	.70
74LS386N	.55
74LS670N	2.59
81LS95N	1.76
81LS96N	1.76
81LS97N	1.76
81LS98N	1.76

4000 CMOS

4000	.40
4001	.31
4002	.35
4006	1.36
4007	.49
4008	1.12
4009	.56
4010	.56
4011	.33
4012	.35
4013	.62
4014	1.08
4015	1.08
4016	.55
4017	1.08
4018	1.08
4019	.56
4020	1.30
4021	1.14
4022	1.08
4023	.35
4024	.94
4025	.38
4027	.74
4028	.99
4029	1.19
4030	.46
4034	2.75
4035	1.42
4040	1.24
4041	1.07
4042	1.08
4043	1.08
4044	1.08
4046	1.79
4047	1.45
4048	.80
4049	.58
4050	.58
4051	1.19
4052	1.19
4053	1.19
4060	1.58
4066	.79
4071	.35
4073	.35
4075	.35
4081	.37
4089	2.75
4093	.76
4099	2.10
4503	.69
4510	1.17
4511	1.28
4512	1.39
4514	2.80
4515	2.80
4516	1.23
4518	1.17
4519	.63
4520	1.17
4522	1.75
4526	1.75
4527	1.68
4528	1.61
4723	1.53
4724	1.53
40106	.90
40160	1.19
40161	1.19
40162	1.19
40163	1.19
40174	1.16
40175	1.16
40192	1.30
40193	1.30
40195	1.19

74C00 CMOS

74C00N	.35
74C02N	.35
74C04N	.35
74C08N	.35
74C10N	.35
74C14N	.90
74C20N	.35
74C30N	.35
74C32N	.35
74C42N	1.03
74C48N	1.28
74C73N	.72
74C74N	.48
74C76N	.72
74C83N	1.51
74C85N	1.51
74C86N	.46
74C90N	1.14
74C93N	1.14
74C95N	1.39
74C107N	.70
74C150N	3.66
74C151N	2.41
74C154N	3.66
74C157N	2.41
74C160N	1.19
74C161N	1.19
74C162N	1.19
74C163N	1.19
74C164N	1.16
74C165N	1.19
74C173N	1.30
74C174N	1.16
74C175N	1.16
74C192N	1.38
74C193N	1.38
74C195N	1.19
74C221N	1.90
74C901N	.48
74C902N	.48
74C908N	1.22
74C909N	2.26
74C914N	1.50
74C922N	5.70
74C923N	5.90
74C925N	7.80
74C926N	7.80
74C927N	7.80
74C928N	7.80
80C95N	.69
80C96N	.69
80C97N	.69
80C98N	.69

LINEAR I.C.'S

LF347N	3.57
LF351N	.78
LF353N	1.40
LF356N	1.48
LF357N	1.48
LF13741N	.76
LM301AN	.58
LM307N	.68
LM308N	1.00
LM311N	.90
LM317K	5.23
LM317MP	2.06
LM317T	3.00
LM318N	2.58
LM320MP-5	1.74
LM320MP-6	1.74
LM320MP-8	1.74
LM320MP-9	1.74
LM320MP-12	1.74
LM320MP-15	1.74
LM320MP-18	1.74
LM320MP-24	1.74
LM322N	2.08
LM323K	8.98
LM324N	.92
LM325N	3.44
LM326N	3.44
LM327N	3.44
LM331N	5.46
LM334Z	1.52
LM335Z	2.25
LM336Z	2.27
LM337K	6.98
LM337T	2.47
LM338K	9.49
LM339N	1.15
LM340KC-5	2.10
LM340T-5	1.32
LM340T-6	1.32
LM340T-12	1.32
LM340T-15	1.32
LM340T-18	1.32
LM340T-24	1.32
LM341P-5	1.04
LM341P-6	1.04
LM341P-8	1.04
LM341P-10	1.04
LM341P-12	1.04
LM341P-15	1.04
LM341P-18	1.04
LM341P-24	1.04
LM348N	1.62
LM349N	1.82
LM350K	7.85
LM358N	1.10
LM377N	2.40
LM378N	3.15
LM392N	1.20
LM379S	5.60
LM380N-8	1.30
LM381N	2.25
LM382N	1.75
LM383AT	3.64
LM386N-1	1.10
LM387N	1.45
LM1310N	1.90
LM1458N	.80
LM1496N	.94
LM1800N	1.75
LM1801N	2.75
LM1812N	6.21
LM1830N	1.75
LM1889N	2.58
LM2111N	1.57
LM2907N	2.57
LM2917N	2.57
LM3046N	.82
LM3086N	.69
LM3089N	2.00
LM3302N	.92
LM3900N	1.07
LM3905N	1.83
LM3909N	.83
LM3911N	1.95
LM3914N	3.75
LM3915	4.55
LM3916	4.29
LM13600N	4.29
NE555CN	.70
NE556CN	1.07
NE565CN	1.33
NE566CN	1.58
NE567CN	1.33
NSM3914N	8.37
NSM3915N	8.37
NSM3916N	8.37
UA709CN	.82
UA723CN	.69
UA733CN	.94
UA741CN	.53
UA747CN	.82
UA748CN	.70
UA7805CK	2.10
UA7805CT	1.32
UA7806CT	1.32
UA7812CT	1.32
U7815CT	1.32
UA7818CT	1.32
UA7824CT	1.32
UA78L05ACZ	.45
UA78L06ACZ	.45
UA78L08ACZ	.45
UA78L10ACZ	.45
UA78L12ACZ	.45
UA78L15ACZ	.45
UA78L24ACZ	.45
UA7905CT	1.70
UA7906CT	1.70
UA7909CT	1.70
UA7912CT	1.70
UA7915CT	1.70
UA7924CT	1.70

INTERFACE I.C.'S

8093N	.64
8094N	.64
8095N	.80
8096N	.80
8097N	.80
8098N	.80
75450N	.92
75451N	.65
75452N	.65
75453N	.65
75454N	.65
75491N	.84
75492N	.84
75493N	1.07
75494N	1.07
MC1488N	1.39
MC1489N	1.39

A/D & D/A CONVERTERS & MISCELLANEOUS

ADC0804LCN	5.79
ACD0817CCN	14.35
ACD0816CCN	29.95
ACD3511CCN	12.02
ADC3711CCN	13.52
ADD3501CCN	11.98
ADD3701CCN	13.52
DAC0800LCN	3.87
DAC0808LCN	3.37
MM5314N	3.98
MM5369N	2.80
MM5837N	2.30

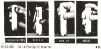
MEMORY

1702A	10.49
2114N	8.33
21L02-1	2.24
2708	16.74
74S189N	2.49
74S570N	5.74
74S571N	5.74
9334N	1.90
93410PC	3.24
MM5257N	8.99
MM5280N-055	4.84
MM5290J-4	15.00
DAC1020LCN	11.37
DAC1022LCN	11.37

MICROPROCESSORS

8228N	6.23	8060N	18.58
8238N	6.11	8080AN	9.97
8251N	8.73	8212N	3.25
8304N	6.75	8216N	3.25
ISP-8F/352	32.75	8224N	3.25
DP8226N	2.47	INS8255N	9.45

DIP IC INSERTION TOOLS WITH PIN STRAIGHTENER



K153-ND	14-16 Pin Cip/IC Inserter	$3.49
K154-ND	14-16 Pin CMOS Safe Inserter	$7.95
K155-ND	24-28 Pin CMOS Safe Inserter	$7.95
K156-ND	36-40 Pin CMOS Safe Inserter	$7.95
K157-ND	Extractor Tool	$1.49

CMOS-SAFE DIP IC EXTRACTOR TOOL

K158-ND	Extractor Tool	$7.95

INSERTION & EXTRACTION KIT

K159-ND	Insertion & Extraction Kit	$29.95

5% CARBON FILM RESISTORS

¼ WATT RESISTOR ASSORTMENTS

RS125	Set of 5 each of the 73 standard 5% ¼ watt carbon film resistors in the series 1.0, 1.2, 1.5, 1.8, 2.2, etc., through 1.0 meghom (365 total pcs.)	$9.90
RS225	Set of 5 each of the 72 standard 5% ¼ watt carbon film resistors in the series 1.1, 1.3, 1.6, 2.0, 2.4, etc., through 910 kilohm (360 total pcs.)	$9.90

½ WATT RESISTORS ASSORTMENTS

RS150	Set of 5 each of the 73 standard 5% ½ watt carbon film resistors in the series 1.0, 1.2, 1.5, 1.8, 2.2, etc., through 1.0 meghom (365 total pcs.)	$9.90
RS250	Set of 5 each of the 72 standard 5% ½ watt carbon film resistors in the series 1.1, 1.3, 1.6, 2.0, 2.4, etc., through 910 kilohm (360 total pcs.)	$9.90

E.F. JOHNSON ALUMINUM SPACERS

Round Tubular

Cat. No.	I.D.	O.D.	Len.	10	100
J166	.115	.250	.187	$1.15	$9.90
J167	.115	.250	.250	1.25	10.80
J168	.140	.250	.125	1.05	9.00
J169	.140	.250	.250	1.25	10.80

Round Threaded

Cat. No.	Thread	O.D.	Len.	10	100
J170	4-40	.250	.375	$1.70	$14.40
J171	4-40	.250	.875	2.50	21.60
J172	4-40	.250	1.25	3.35	28.80
J173	6-32	.250	.625	1.80	15.30

Hex Threaded

Cat. No.	Thread	O.D.	Len.	10	100
J174	4-40	.250	.375	$1.90	$16.20
J175	4-40	.250	.625	2.30	19.80
J176	4-40	.250	.875	2.30	19.80
J177	6-32	.250	.250	1.45	12.30
J178	6-32	.250	.500	2.10	18.00
J179	6-32	.250	.625	2.30	19.80
J180	6-32	.250	.750	2.15	18.30
J181	6-32	.250	1.00	2.95	25.20

MOLEX I.C. SOCKET PINS

.95/C	9.10/M	42.00/5M	300.00/50M

TEXAS INSTRUMENTS I.C. SOCKETS

SOLDER TAIL DIP SOCKETS

- Low profile
- Face grip design for maximum rentention force
- Redundant contact points
- YOUR CHOICE — TIN OR GOLD*
  (*Minimum of 50 microinches gold inlay on gold sockets)
- TEXAS INSTRUMENTS QUALITY

TIN INLAY SOLDER TAIL — Min. 200 Microinches Tin

Part No.	Description	1	10	100
C8508	8 pin solder tab tin	.10	.88	8.00
C8514	14 pin solder tab tin	.17	1.53	14.00
C8516	16 pin solder tab tin	.20	1.76	16.00
C8518	18 pin solder tab tin	.22	1.98	18.00
C8520	20 pin solder tab tin	.25	2.21	20.00
C8522	22 pin solder tab tin	.27	2.43	22.00
C8524	24 pin solder tab tin	.30	2.65	24.00
C8528	28 pin solder tab tin	.35	3.11	28.00
C8540	40 pin solder tab tin	.49	4.41	40.00

GOLD INLAY SOLDER TAIL — Min. 50 Microinches Gold

Part No.	Description	1	10	100
C9508	8 pin solder tab gold	.28	2.48	22.00
C9514	14 pin solder tab gold	.32	2.81	25.00
C9516	16 pin solder tab gold	.37	3.26	29.00
C9518	18 pin solder tab gold	.42	3.72	33.00
C9520	20 pin solder tab gold	.47	4.16	37.00
C9522	22 pin solder tab gold	.50	4.50	40.00
C9524	24 pin solder tab gold	.54	4.84	43.00
C9528	28 pin solder tab gold	.63	5.63	50.00
C9540	40 pin solder tab gold	.90	8.10	72.00

WIRE WRAP DIP SOCKETS

- Standard profile
- Universal mounting and packaging capabilities
- Contacts accommodate .015" through .021" rectangular or round dual-in-line leads
- Wire wrap posts held to true position of .015" providing a true position of .020" on boards for efficient automatic wire wrapping
- YOUR CHOICE — TIN OR GOLD*
  (*Minimum .50 microinch gold inlay on gold sockets)
- TEXAS INSTRUMENTS QUALITY

TIN PLATED WIRE WRAP — Min. 200 Microinches Tin

Part No.	Description	1	10	100
C8108	8 pin wire wrap tin	.33	2.93	26.00
C8114	14 pin wire wrap tin	.38	3.70	36.00
C8116	16 pin wire wrap tin	.42	4.10	40.00
C8118	18 pin wire wrap tin	.55	4.95	44.00
C8120	20 pin wire wrap tin	.78	6.98	62.00
C8122	22 pin wire wrap tin	.80	7.20	64.00
C8124	24 pin wire wrap tin	.83	7.43	66.00
C8128	28 pin wire wrap tin	1.05	9.45	84.00
C8140	40 pin wire wrap tin	1.58	14.18	126.00

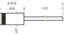
GOLD INLAY WIRE WRAP — Min. 50 Microinches Gold

Part No.	Description	1	10	100
C9108	8 pin wire wrap, gold	.49	4.35	41.10
C9114	14 pin wire wrap, gold	.82	7.45	69.95
C9116	16 pin wire wrap, gold	.91	8.20	77.15
C9118	18 pin wire wrap, gold	.99	8.95	84.40
C9120	20 pin wire wrap, gold	1.30	11.25	111.00
C9122	22 pin wire wrap, gold	1.33	11.95	113.05
C9124	24 pin wire wrap, gold	1.36	12.25	115.40
C9128	28 pin wire wrap, gold	1.81	16.35	154.10
C9140	40 pin wire wrap, gold	2.58	23.20	218.90

SILICON TRANSISTORS

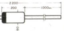
	1	10	100	1000
2N3904	.20	1.79	16.25	146.25
2N3906	.20	1.79	16.25	146.25
2N4124	.21	1.93	17.50	157.50
2N4126	.22	2.01	18.25	164.25
2N4401	.21	1.93	17.50	157.50
2N4403	.21	1.93	17.50	157.50
2N4410	.30	2.70	24.38	219.38
2N5087	.24	2.20	20.00	180.00
2N5089	.24	2.20	20.00	180.00
2N5210	.27	2.48	22.50	202.50
2N5457	.54	4.86	43.88	394.88
92PU01A	.38	3.42	30.88	277.88
92PU10	.38	3.42	30.88	277.88
92PU45A	.41	3.69	33.32	299.82
92PU51A	.38	3.42	30.88	277.88
MJ2955	1.47	13.48	122.50	1102.25
MJE172	.74	6.66	60.13	541.13
MJE182	.72	6.48	58.50	526.50
MJE3439	.56	4.80	40.00	360.00
MJE344	.68	6.12	55.25	497.25
MJE370	.89	8.01	72.32	650.82
MJE371	1.10	9.90	89.38	804.38
MJE520	.86	7.74	69.88	628.88
MJE521	.86	7.74	69.88	628.88
MJE703	1.13	10.17	91.82	826.31
MJE712	.74	6.66	60.13	541.13
MJE722	.74	6.66	60.13	541.13
MJE803	1.01	9.09	82.07	738.57
MPF102	.54	4.95	45.00	405.00
MPS2222A	.21	1.93	17.50	157.50
MPS2369A	.24	2.20	20.00	180.00
MPS2907A	.24	2.20	20.00	180.00
MPS3392	.23	2.07	18.75	169.00
MPS3393	.21	1.93	17.50	157.50
MPS3394	.24	2.20	20.00	180.00
MPS3395	.24	2.20	20.00	180.00
MPS3563	.21	1.93	17.50	157.50
MPS3565	.21	1.93	17.50	157.50
MPS3638A	.21	1.93	17.50	157.50
MPS3641	.21	1.93	17.50	157.50
MPS3643	.21	1.93	17.50	157.50
MPS918	.22	1.98	17.88	160.88
MPS930	.21	1.93	17.50	157.50
MPSA13	.27	2.48	22.50	202.50
TIP112	.98	8.40	70.00	630.00
TIP117	1.12	10.08	91.00	819.00
TIP120	1.17	10.73	97.50	877.50
TIP122	1.54	13.20	110.00	990.00
TIP127	1.54	13.20	110.00	990.00
TIP132	2.32	20.88	188.50	1696.50
TIP135	2.32	20.88	188.50	1696.50
TIP29C	.81	6.90	57.50	517.50
TIP30C	.81	6.90	57.50	517.50
TIP31C	.98	8.40	70.00	630.00
TIP32C	1.02	8.70	72.50	652.50
TIP61C	.81	6.90	57.50	517.50
TIP62C	.81	6.90	57.50	517.50

ITT RECTIFIERS



Cat. No.	Description	Pkg.	10	100	1000	10,000
1N4001	1 Amp 50 PIV Silicon Rectifier	DO-41	.80	7.00	60.00	540.00
1N4002	1 Amp 100 PIV silicon Rectifier	DO-41	.80	7.00	60.00	540.00
1N4003	1 Amp 200 PIV Silicon Rectifier	DO-41	.80	7.50	64.00	576.00
1N4004	1 Amp 400 PIV Silicon Rectifier	DO-41	.80	7.90	68.00	612.00
1N4005	1 Amp 600 PIV Silicon Rectifier	DO-41	1.00	8.00	74.00	666.00
1N4006	1 Amp 800 PIV Silicon Rectifier	DO-41	1.00	9.00	80.00	720.00
1N4007	1 Amp 1000 PIV Silicon Rectifier	DO-41	1.00	9.00	88.00	800.00
1N4148	Ultra Fast Switching Diode (1N914 equiv.)	DO-41	.60	5.00	32.00	276.60

ITT SILICON ZENER DIODES



Catalog Number	Description	Unit Price	10
1N5226B	3.3 V 5% 500mW Zener (1N746A equiv.)	.24	1.80
1N5227B	3.6 V 5% 500mW Zener (1N747A equiv.)	.24	1.80
1N5228B	3.9 V 5% 500mW Zener (1N748A equiv.)	.24	1.80
1N5229B	4.3 V 5% 500mW Zener (1N749A equiv.)	.24	1.80
1N5230B	4.7 V 5% 500mW Zener (1N750A equiv.)	.24	1.80
1N5231B	5.1 V 5% 500mW Zener (1N751A equiv.)	.24	1.80
1N5232B	5.6 V 5% 500mW Zener (1N752A equiv.)	.24	1.80
1N5233B	6.0 V 5% 500mW Zener	.24	1.80
1N5234B	6.2 V 5% 500mW Zener (1N753A equiv.)	.24	1.80
1N5235B	6.8 V 5% 500mW Zener (1N754A equiv.)	.24	1.80
1N5236B	7.5 V 5% 500mW Zener (1N958B equiv.)	.24	1.80
1N5237B	8.2 V 5% 500mW Zener (1N959B equiv.)	.24	1.80
1N5238B	8.7 V 5% 500mW Zener	.24	1.80
1N5239B	9.1 V 5% 500mW Zener (1N960B equiv.)	.24	1.80
1N5240B	10 V 5% 500mW Zener (1N961B equiv.)	.24	1.80
1N5241B	11 V 5% 500mW Zener (1N962B equiv.)	.24	1.80
1N5242B	12 V 5% 500mW Zener (1N963B equiv.)	.24	1.80
1N5243B	13 V 5% 500mW Zener (1N964B equiv.)	.24	1.80
1N5244B	14 V 5% 500mW Zener	.24	1.80
1N5245B	15 V 5% 500mW Zener (1N965B equiv.)	.24	1.80
1N5246B	16 V 5% 500mW Zener (1N966B equiv.)	.24	1.80
1N5247B	17 V 5% 500mW Zener	.24	1.80
1N5248B	18 V 5% 500mW Zener (1N967B equiv.)	.24	1.80
1N5249B	19 V 5% 500mW Zener	.24	1.80
1N5250B	20 V 5% 500mW Zener (1N968B equiv.)	.24	1.80
1N5251B	22 V 5% 500mW Zener (1N969B equiv.)	.24	1.80
1N5252B	24 V 5% 500mW Zener (1N970B equiv.)	.24	1.80
1N5253B	25 V 5% 500mW Zener	.24	1.80
1N5254B	27 V 5% 500mW Zener (1N971B equiv.)	.24	1.80
1N5255B	28 V 5% 500mW Zener	.24	1.80
1N5256B	30 V 5% 500mW Zener (1N972B equiv.)	.24	1.80
1N5257B	33 V 5% 500mW Zener (1N973B equiv.)	.24	1.80

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HOBBY-BLOX

THE NEW MODULAR CIRCUIT BUILDING SYSTEM

Whether you're a beginner or an advanced hobbyist, Hobby-Blox is the right system for you. The Hobby-Blox System takes you as far as your imagination will go. Begin at the beginning with a Hobby-Blox starter pack. You can expand the Hobby-Blox System with a complete line of modules.

BASIC INTEGRATED CIRCUIT STARTER PACK
The IC Starter Pack includes two terminal strips, two distribution strips and a spacer/support strip, already in a Hobby-Blox tray, ready for use. A free project booklet containing ten IC projects with step-by-step instructions completes the pack. Purchase of the IC Starter Pack saves you one dollar over price of modules purchased separately.
Part No. 921490-R **$5.97**

INTEGRATED CIRCUIT STARTER PACK COMPONENTS
Order Part No. 921491-R **$11.95**

BASIC DISCRETE COMPONENT STARTER PACK
This starter pack contains a tray, discrete component strip, battery holder and connector (battery not included) and project booklet with ten projects. Purchase of the Discrete Component Starter Pack saves you one dollar over price of modules purchased separately.
Part No. 921480-R **$6.57**

DISCRETE COMPONENT STARTER PACK COMPONENTS
Order Part No. 921481-R **$6.25**

TRAY Part No. 921500-R **$1.98**
All modules fit easily into the Hobby-Blox tray which is the basis for the entire Hobby-Blox system.

DISTRIBUTION STRIPS Part No. 921510-R **$1.99**
Includes two distribution strips, each of which has two continuous 26 tie-point terminals. With the Hobby-Blox distribution strips, it's easy to connect your circuitry to power and ground.

3x36 TERMINAL STRIPS Part No. 921505-R **$2.99**
Two terminal strips and a spacer/support strip make up this pack. Each terminal strip contains 26 3 tie-point terminals.

BLANK PANEL PACK Part No. 921550-R **$1.69**
A custom piece for any hobbyist. The blank panel allows you to drill holes in any manner of configuration to suit any mounting you desire.

BUS STRIP Part No. 921520-R **$2.99**
This Hobby-Blox module contains two continuous rows of 60 tie-point terminals for easy power and ground busing the entire length of the tray and also between trays with its unique tray interlocking features.

3x16 TERMINAL STRIP Part No. 921525-R **$2.99**
Consists of three patterns of terminals with each pattern containing two rows of eight contracts. This strip will accept three each 7 segment displays, 14 or 16 pin DIPS.

L.E.D. STRIP Part No. 921530-R **$1.99**
Accepts six LEDs and includes a common BUS for current limiting resistor

DISCRETE COMPONENT STRIP Part No. 921515-R **$2.99**
This module is the answer to breadboarding circuits with larger components. It contains 14 terminals, each with five tie-points. The tie-points are spaced .2" apart both vertically and horizontally.

BINDING POST STRIP Part No. 921560-R **$3.59**
Includes three five-way binding posts. Each binding post is electronically connected to a solderless plug-in tie-point.

TRAY EXTENDER CLIPS Part No. 921570-R **$1.29**
Expandability is not only side-by-side with the Hobby-Blox system. The tray extender clips allow you to attach trays end-to-end also! Includes four clips.

CONTROL PANEL PACK Part No. 921545-R **$1.69**
Includes two control panels and two spacer/support strips. Accepts a wide variety of switches and indicators.

SPEAKER PANEL PACK Part No. 921540-R **$1.69**
Includes two speaker panels and two spacer/support strips. Readily accepts a 2" or smaller diameter speaker.

BATTERY HOLDER PACK Part No. 921555-R **$2.59**
Includes battery holder and connector for a 9-volt battery. (Battery not included)

VERTICAL TRAY PACK Part No. 921535-R **$1.69**
Includes a smaller tray and an adaptor strip that allows you to mount the tray perpendicular to the horizontal tray.

SUPER-STRIPS

UNIVERSAL BREADBOARDING ELEMENTS WITH SOLDERLESS PLUG-IN TIE POINTS

The A P Super-Strips combine a power signal distribution system with a matrix of 128 terminals, each with 5 tie points. The distribution system consists of eight buses, each individual bus consisting of a line of 25 tie points. All tie points are the solderless, plug-in type of the same design used on A P terminal Strips and A P Distribution Strips.

923252	(Alloy 770 Terminals)	**17.00**
923748	(Gold-plated Terminals)	**29.95**

POWERACE

For faster and easier prototyping. They have built in power supplies

Powerace 101
With plus-5 to plus-15 VDC adj power supply, No. 923101 **$ 79.95**

Powerace 103
Triple-output power supply for digital & linear, No. 923103 **$124.95**
Other equipment, too numerous to mention, available.

Powerace 102
A digital lab including a logic probe & clock, No. 923102 **$124.95**

For complete AP Products specifications get your FREE DIGI-KEY catalog today

TEXAS INSTRUMENTS GOLD EDGEBOARD CONNECTORS

RELIABLE, COST-EFFICIENT CONTACT DESIGN

- 50 (Wire Wrap) to 50 (solder Tail) micro-inches gold inlay over a nickel diffusion barrier.
- Copper-nickel-tin CA 725 alloy.
- Bifurcated contact points.
- Preloaded, cantilever spring design.
- Contacts are user removable.

*NOTE — Dimensions below are the pin center to center measurement followed by the distance separating the two pin rows.

H4 SERIES .100"x.200" EDGEBOARD CONNECTORS

Positions Contacts	Part No. Wire Wrap	1	10	100	Part No. Solder Tail	1	10	100
10 20	C6-10	2.22	20.40	167.00	C5-10	2.10	19.30	158.00
15 30	C6-15	2.55	23.40	191.00	C5-15	2.37	21.70	178.00
17 34	C6-17	2.73	25.00	205.00	C5-17	2.52	23.10	189.00
18 36	C6-18	2.88	26.40	216.00	C5-18	2.61	23.90	196.00
20 40	C6-20	3.09	28.30	232.00	C5-20	2.76	25.30	207.00
22 44	C6-22	3.36	30.80	252.00	C5-22	2.97	27.20	223.00
25 50	C6-25	3.75	34.40	281.00	C5-25	3.27	30.00	245.00
28 56	C6-28	3.99	36.60	299.00	C5-28	3.54	32.50	266.00
30 60	C6-30	4.14	38.00	311.00	C5-30	3.75	34.40	281.00
31 62	C6-31	4.32	39.60	324.00	C5-31	3.84	35.20	288.00
35 70	C6-35	4.89	44.80	367.00	C5-35	4.20	38.50	315.00
36 72	C6-36	4.95	45.40	371.00	C5-36	4.32	39.60	324.00
40 80	C6-40	5.49	50.30	412.00	C5-40	4.71	43.20	353.00
43 86	C6-43	5.91	54.20	443.00	C5-43	4.98	45.70	374.00
49 98	C6-49	6.72	61.60	504.00	C5-49	5.58	51.20	419.00
50 100	C6-50	6.81	62.40	511.00	C5-50	5.64	51.70	423.00

for polarizing keys order P/N CR1164-2 .10/ea. 7.50/100

H4 SERIES .125"x.250" EDGEBOARD CONNECTORS

Positions Contacts	Part No. Wire Wrap	1	10	100	Part No. Solder Tail	1	10	100
10/20	C4-10	2.37	21.70	178.00	C3-10	2.13	19.50	160.00
15/30	C4-15	2.73	25.00	205.00	C3-15	2.46	22.60	185.00
18/36	C4-18	2.97	27.20	223.00	C3-18	2.67	24.50	200.00
20/40	C4-20	3.24	29.70	243.00	C3-20	2.85	26.10	214.00
22/44	C4-22	3.48	31.90	261.00	C3-22	3.00	27.50	225.00
25/50	C4-25	3.90	35.80	293.00	C3-25	3.39	31.10	254.00
28/56	C4-28	4.11	37.70	308.00	C3-28	3.69	33.80	277.00
30/60	C4-30	4.29	39.30	322.00	C3-30	3.81	34.90	286.00
31/62	C4-31	4.44	40.70	333.00	C3-31	4.05	37.10	304.00
35/70	C4-35	5.01	45.90	376.00	C3-35	4.50	41.30	338.00
36/72	C4-36	5.10	46.80	383.00	C3-36	4.56	41.80	342.00
40/80	C4-40	5.64	51.70	423.00	C3-40	5.04	46.20	378.00
44/88	C4-44	6.09	55.80	457.00	C3-44	5.49	50.30	412.00
50/100	C4-50	6.90	63.30	518.00	C3-50	6.18	56.70	464.00

for polarizing keys order P/N CR1164-2 .10/ea. 7.50/100

H4 SERIES .156"x.200" EDGEBOARD CONNECTORS

Positions Contacts	Part No. Solder Tail	1	10	100	Part No. Solder Eye	1	10	100
10 20	C1-10	2.49	22.80	187.00	C2-10	4.08	37.40	306.00
12 24	C1-12	2.64	24.20	198.00	C2-12	4.32	39.60	324.00
15 30	C1-15	2.94	27.00	221.00	C2-15	4.71	43.20	353.00
18 36	C1-18	3.18	29.20	239.00	C2-18	4.98	45.70	374.00
22 44	C1-22	3.54	32.50	266.00	C2-22	5.49	50.30	412.00
25 50	C1-25	3.84	35.20	288.00	C2-25	5.91	54.20	443.00
28 56	C1-28	4.29	39.30	322.00	C2-28	6.36	58.30	477.00

for polarizing keys order P/N CR1164-1 .10/ea. 7.50/100

ELECTRONIC HARDWARE KIT

1600 pieces of zinc plated hardware complete with divided plastic box for easy storage

ELECTRONIC HARDWARE KIT CONTAINS:

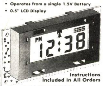
100 2-56x1/4 Machine Screws	100 8-32x5/8 Machine Screws
100 2-56x1/2 Machine Screws	100 2-56 Hex Nuts
100 4-40x1/4 Machine Screws	100 4-40 Hex Nuts
100 4-40x1/2 Machine Screws	100 6-32 Hex Nuts
100 6-32x1/4 Machine Screws	100 8-32 Hex Nuts
100 6-32x1/2 Machine Screws	100 No. 2 Internal Tooth Lock Washers
100 8-32x3/8 Machine Screws	100 No. 4 Internal Tooth Lock Washers
	100 No. 6 Internal Tooth Lock Washers
	100 No. 8 Internal Tooth Lock Washers

CAT. NO. 1600 KIT
$14.95

"NEW" MA1032 Clock

Digital LCD Clock Module

- Operates from a single 1.5V Battery
- 0.5" LCD Display



Instructions Included In All Orders

- User selectable 12 or 24-hour mode
- 24-hour alarm with ON-OFF control
- Presetable 59-minute sleep timer with reset to zero
- 7-minute snooze timer
- Fast/Slow setting controls
- Seconds display
- 90 mA hour battery will typically last one year
- Minimum external parts required for travel clock/clock radio
- Backlighted Display

Catalog No.	Description	Cost
MA1032M	LCD Clock Module only	$24.95
MA1032C	Switch for MA1032M	$ 2.85
MA1032R	MA1032M, MA1032C, & AA battery holder	$28.20

TIME-TEMPERATURE PROGRAMMABLE MODULE

USER PROGRAMMABLE FOR:

- 12 or 24 Hour Display
- F and/or C, as well as virtually any number of temperature sensors
- Fixed or flashing colon format
- 50/60 Hz line Frequency operation

MA 1026 by National Semiconductor

Instruction included with all orders

FEATURES

- Giant 0.7 inch — 4 digit LED display with red lens.
- PM, colon, degree and alarm "ON" LED indicators.
- 6 display modes - temperature, time, seconds, alarm, sleep and lamp test.
- Exclusive Digi-Key switching panel available to simplify hook-up.
- Leading zero blanking.
- time is normal display mode, with temperature display at push of switch.
- displays temperatures in range of -40°C to 90°C.
- Power fail condition indicated by flashing.
- Addition of simple circuit will allow switching of small to medium AD loads.

Cat. No.	Description	Cost
MA1026M	MA1026 Clock Module (Assembled and tested)	$19.95
MA1026P	Digi-Key Switching Panel Kit for MA1026M (includes P.C. Board, switches, hardware, two temperature sensors, two potentiometers)	11.95
MA1026T	Special transformer for MA1026M	2.95
MA1026B	**Alarm buzzer for MA1026M**	3.00
MA1026K	Includes MA1026M P, T, and B	34.95
MA1026X	3.58 Megahertz Crystal	3.95
MA1026C	Conventional Switch Set for applications where MA1026P is not used includes one 501PB and ten 502PB switches	3.95
MA1026R	Includes MA1026M, MA1026C, MA1026T, two temperature sensors and two potentiometer	29.95

For each additional sensor unit, the following are suggested:

LM334	Temperature transducer for MA1026M Module	1.53
KOA32	300 ohm potentiometer for LM334 transducer	.32
502PB	Normally open switch	.45

THE "PROGRAMMABLE" CLOCK MODULES

USER PROGRAMMABLE FOR:

- 12 or 24 hour display
- fixed or flashing colon
- 50/60 Hz line frequency operation

FEATURES:

- Display brightness can be controlled by introduction of potentiometer
- Back-up time keeping with introduction of 5M potentiometer & 9V battery
- Alarm involves adding buzzer—no intervening circuitry
- Your Choice — 0.7" or 0.84" red LED display
- Low power consumption
- Leading zero blanking
- Optional switching panel to simplify hook-up

MA1023 — 0.7" HIGH DIGITS

Cat. No.	Description	Cost
MA1023M	MA1023 Clock Module Only (Assembled and tested)	$ 9.95
MA1023P	Digi-Key Switching Panel Kit for MA1023 (Includes P.C. Board, Switches, Hardware and Components)	6.95
MA1023T	Special Transformers for MA1023	2.95
MA1023B	Alarm Buzzer for MA1023	3.00
MA1023K	Includes MA1023M, P, T, & B.	19.95
MA1023C	Conventional switch set for applications, where MA1023P is not used, includes one 501PB and 502PB.	3.10
MA1023R	Clock Module, Conventional Switches, Transformer	14.95

MA1020 — 0.84" HIGH DIGITS

Cat. No.	Description	Cost
MA1020M	MA1020 Clock Module (Assembled and tested)	$13.95
MA1020P	Digi-key Switching Panel Kit for MA1020 (Includes P.C. Board, Switches, Hardware, Components)	7.95
MA1020T	Special Transformer for MA1020M	3.25
MA1020B	Alarm Buzzer for MA1020M	3.00
MA1020K	Includes MA1020M, P, T, & B.	26.95
MA1020C	Conventional switch set for applications where MA1020P is not used, includes one 501PB and six 502PB and a 3M ohm resistor, trimmer, battery snaps.	3.50
MA1020R	Includes MA1020M, MA1020C & MA1020T	19.95

DIGITAL CLOCK BEZEL

THE J.M.J. DIGITAL DISPLAY BEZEL

WITH RED FILTER
Part No. 400

UNIVERSAL SIZE
HANDLES MOST REQUIREMENTS
Be Sure to Order the Proper Adapter for Your Digital Clock

Part	Description	Price
400	Digital Display BEZEL with Red Filter	$ 4.95
420	Mounting Adapters for MA1001, MA1002, etc.	.69
421	Mounting Adapters for MA1010, MA1020, MA1026	.69
422	Universal PC Board Mounting Adapters	.69
423	Mounting Adapter for MA1023	.69

DIGI-CLOCK KIT

- 12 VDC — Ideal for Car, Van or Boat!

- Trouble-free Module!
- 270° Swivel Mount
- Inlaid Walnut Chrome Trim Bezel!
- Ideal for Car, Van or Boat!
- 3-5/8"x2-3/16" Tall x 2-1/8" Deep!
- Quick and Easy to Install!

Part No. 5001K
ONLY $24.95

Do you need spacers, Banana plugs and jacks, or tip plugs and jacks? You can get these and more E. F. JOHNSON products from DIGI-KEY.

HEAT SINKS from TO-92 2W coolers to TO-3 100W sinks.

PANASONIC ELECTROLYTIC CAPACITORS

Value UF	WV D.C.	Axial 1	Axial 10	Axial 100	Radial 1	Radial 10	Radial 100
22	/6.3	.18	1.54	12.83	—	—	—
33	/6.3	.20	1.68	14.04	.14	1.12	9.31
47	/6.3	.21	1.74	14.48	.14	1.16	9.59
100	/6.3	.22	1.83	15.22	.16	1.33	11.05
220	/6.3	.28	2.34	19.53	.21	1.78	14.80
330	/6.3	.29	2.46	20.48	.23	1.92	15.95
470	/6.3	.33	2.78	23.15	.23	1.97	16.34
1000	/6.3	.49	4.20	35.00	.36	3.08	25.62
2200	/6.3	.60	5.13	42.75	.54	4.56	37.95
3300	/6.3	.81	6.94	57.83	.75	6.38	53.10
4700	/6.3	1.04	8.89	74.07	.93	7.95	66.20
6800	/6.3	1.27	10.87	90.58	1.13	9.68	80.62
10000	/6.3	1.54	13.17	109.77	1.54	13.13	109.40
22	/10	.18	1.54	12.83	.13	1.08	8.94
33	/10	.21	1.74	14.48	.14	1.16	9.59
47	/10	.21	1.77	14.78	.14	1.19	9.90
100	/10	.24	2.00	16.65	.17	1.39	11.58
220	/10	.29	2.46	20.48	.23	1.92	15.95
330	/10	.33	2.78	23.15	.24	2.06	17.10
470	/10	.44	3.72	30.97	.35	2.97	24.69
1000	/10	.55	4.63	38.62	.41	3.42	28.45
2200	/10	.78	6.63	55.28	.70	5.93	49.42
3300	/10	.99	8.45	70.38	.90	7.71	64.22
4700	/10	1.28	10.94	91.18	1.13	9.68	80.62
6800	/10	1.55	13.26	110.52	1.54	13.20	109.40
10000	/10	1.99	17.00	141.63	—	—	—
10	/16	.18	1.54	12.83	.13	1.08	8.94
22	/16	.21	1.74	14.48	.14	1.15	9.52
33	/16	.21	1.77	14.77	.14	1.19	9.90
47	/16	.24	2.00	16.65	.16	1.36	11.31
100	/16	.28	2.34	19.53	.21	1.78	14.80
220	/16	.33	2.78	23.15	.24	2.06	17.10
330	/16	.44	3.72	30.97	.35	2.97	24.69
470	/16	.50	4.22	35.14	.38	3.19	26.58
1000	/16	.60	5.09	42.45	.50	4.21	35.08
2200	/16	.92	7.85	65.39	.87	7.46	62.10
3300	/16	1.16	9.91	82.62	1.17	10.01	83.48
4700	/16	1.57	13.40	111.68	1.57	13.43	111.87
6800	/16	1.99	17.00	141.63	—	—	—
2.2	/25	.18	1.54	12.83	—	—	—
3.3	/25	.18	1.54	12.83	.13	1.08	8.94
4.7	/25	.18	1.54	12.83	.13	1.08	8.94
10	/25	.18	1.54	12.83	.14	1.15	9.52
22	/25	.22	1.83	15.22	.15	1.22	10.17
33	/25	.24	2.00	16.65	.17	1.38	11.50
47	/25	.28	2.34	19.53	.21	1.73	14.42
100	/25	.33	2.78	23.15	.23	1.90	15.77
220	/25	.44	3.75	31.24	.40	3.42	28.45
330	/25	.50	4.26	35.47	.52	4.45	37.08
470	/25	.58	4.95	41.24	.64	5.42	45.13
1000	/25	.84	7.18	59.84	.83	7.06	58.78
2200	/25	1.16	9.91	82.62	1.17	10.02	83.47
3300	/25	1.61	13.77	114.77	1.66	14.17	118.03
4700	/25	1.99	17.00	141.63	—	—	—
2.2	/35	.18	1.54	12.83	—	—	—
3.3	/35	.18	1.54	12.83	.13	1.11	9.20
4.7	/35	.18	1.54	12.83	.13	1.11	9.20
10	/35	.21	1.77	14.78	.14	1.19	9.90
22	/35	.24	2.00	16.65	.19	1.60	13.30
33	/35	.28	2.34	19.53	.21	1.78	14.80
47	/35	.33	2.78	23.15	.23	1.90	15.77
100	/35	.43	3.65	30.40	.24	2.06	17.10
220	/35	.51	4.34	36.17	.40	3.42	28.45
330	/35	.57	4.85	40.40	.52	4.45	37.08
470	/35	.65	5.51	45.89	.64	5.42	45.13
1000	/35	.98	8.38	69.80	.92	7.84	65.32
2200	/35	1.61	13.77	114.71	1.66	14.17	118.03
3300	/35	1.99	17.00	141.63	—	—	—
4700	/35	2.61	22.31	185.88	—	—	—
0.47	/50	.18	1.54	12.83	.13	1.08	8.94
1	/50	.18	1.54	12.83	.13	1.08	8.94
1	/50	.18	1.54	12.83	.13	1.08	8.94
2.2	/50	.18	1.54	12.83	.13	1.08	8.94
3.3	/50	.18	1.54	12.83	.14	1.15	9.52
4.7	/50	.21	1.77	14.77	.14	1.18	9.78
10	/50	.24	2.00	16.65	.16	1.35	11.20
22	/50	.28	2.34	19.53	.22	1.83	15.19
33	/50	.32	2.69	27.43	.23	1.90	15.77
47	/50	.36	3.04	25.33	.24	2.05	17.03
100	/50	.45	3.78	31.54	.36	3.08	25.62
220	/50	.61	5.18	43.15	.52	4.45	37.08
330	/50	.76	6.50	54.14	.83	7.06	58.78
470	/50	.92	7.87	65.55	.92	7.84	65.32
1000	/50	1.25	10.71	89.27	1.31	11.16	92.93
2200	/50	1.99	17.00	141.63	—	—	—
0.47	/63	.18	1.54	12.83	.13	1.12	9.32
1	/63	.18	1.54	12.83	.13	1.12	9.32
2.2	/63	.18	1.54	12.83	.14	1.15	9.52
3.3	/63	.21	1.77	14.77	.15	1.25	10.35
4.7	/63	.24	2.00	16.65	.16	1.34	11.13
10	/63	.28	2.34	19.53	.18	1.50	12.43
22	/63	.33	2.78	23.15	.24	2.02	16.79
33	/63	.37	3.12	26.04	.27	2.24	18.60
47	/63	.53	4.51	37.62	.38	3.18	26.45
100	/63	.56	4.76	39.64	.50	4.24	35.27
220	/63	.76	6.50	54.14	.78	6.61	55.02
330	/63	.92	7.87	65.55	.92	7.84	65.32
470	/63	1.05	8.94	74.52	.99	8.43	70.19
1000	/63	1.64	13.99	116.55	1.66	14.17	118.03
2200	/63	2.61	22.31	185.89	—	—	—
0.47	/100	.18	1.54	12.83	.14	1.19	9.90
1	/100	.18	1.54	12.83	.14	1.19	9.90
2.2	/100	.22	1.83	15.22	.15	1.25	10.35
3.3	/100	.24	2.00	16.65	.17	1.38	11.50
4.7	/100	.28	2.34	19.53	.17	1.41	11.70
10	/100	.33	2.78	23.15	.22	1.83	15.19
22	/100	.43	3.65	30.40	.27	2.27	18.90
33	/100	.45	3.85	32.12	.34	2.88	24.00
47	/100	.54	4.62	38.49	.41	3.50	29.14
100	/100	.74	6.29	52.43	.57	4.83	40.22
220	/100	1.09	9.26	77.18	.96	8.22	68.47
330	/100	1.30	11.10	92.53	1.25	10.70	89.13
470	/100	1.81	15.46	128.80	1.78	15.25	127.04
1000	/100	3.16	27.09	225.72	—	—	—

PANASONIC METALLIZED POLYESTER CAPACITORS

250 VDC plus minus 10% TOLERANCE

NEW! KIT
170 METALIZED POLYESTER CAPACITORS
Price includes convenient divided plastic box with bin guide for easy storage and quick access.
ASSORTMENT OF 15 POPULAR VALUES PANASONIC QUALITY

CAT. NO. E-KIT
ONLY $54.95

PART NO.	CAP (UFD)	1	10	100	1000
E2103	.01	.19	1.64	13.68	123.08
E2123	.012	.19	1.64	13.68	123.08
E2153	.015	.19	1.64	13.68	123.08
E2183	.018	.19	1.64	13.68	123.08
E2223	.022	.19	1.64	13.68	123.08
E2273	.027	.19	1.64	13.68	123.08
E2333	.033	.19	1.64	13.68	123.08
E2393	.039	.19	1.64	13.68	123.08
E2473	.047	.19	1.64	13.68	123.08
E2563	.056	.22	1.85	15.43	138.83
E2683	.068	.22	1.85	14.53	138.83
E2823	.082	.22	1.85	15.43	138.83
E2104	.10	.23	1.94	16.13	145.13
E2124	.12	.25	2.12	17.63	158.63
E2154	.15	.27	2.28	18.95	170.55
E2184	.18	.29	2.49	20.73	186.53
E2224	.22	.32	2.68	22.28	200.48
E2274	.27	.34	2.91	24.25	218.25
E2334	.33	.37	3.18	26.47	238.17
E2394	.39	.41	3.44	28.65	257.85
E2474	.47	.43	3.68	30.65	275.85
E2564	.56	.47	4.02	33.45	301.05
E2684	.68	.52	4.43	36.93	332.33
E2824	.82	.58	4.94	41.13	370.13
E2105	1.0	.63	5.35	44.52	400.62
E2125	1.2	.68	5.82	48.50	436.50
E2155	1.5	.86	7.32	60.97	548.67
E2185	1.8	1.01	8.64	72.00	648.00
E2225	2.2	1.03	8.85	73.68	663.08

PANASONIC K-SERIES CAPACITORS

New Panasonic Kseries are miniature, low cost aluminum electrolytic capacitors. Their size and performance characteristics make them viable alternatives to tantalums in many applications.

CAPACITANCE TOLERANCE: 20%
D.C. LEAKAGE CURRENT, MAX. 1 0.01 C V OR 3uA
ALL K-SERIES CAPACITORS WE CARRY ARE RADIAL

DIGI-KEY PART NO.	CAPACITANCE UF	WORKING VOLTAGE DC	1	10 PAK
P800	22	6.3	.24	2.03
P801	33		.25	2.13
P802	47		.26	2.18
P803	100		.30	2.56
P804	22	10	.25	2.13
P805	33		.26	2.23
P806	47		.28	2.37
P807	10	16	.25	2.07
P808	22		.27	2.28
P809	33		.29	2.45
P810	47		.32	2.72
P811	3.3	25	.24	2.03
P812	4.7		.24	2.03
P813	10		.25	2.13
P814	22		.29	2.45
P815	33		.33	2.76
P816	3.3	35	.24	2.03
P817	.47		.25	2.07
P818	10		.26	2.23
P819	22		.32	2.23
P820	.1	50	.24	2.72
P821	.22		.24	2.03
P822	.33		.24	2.03
P823	.47		.24	2.03
P824	1.0		.24	2.03
P825	2.2		.24	2.03
P826	3.3		.25	2.07
P827	4.7		.25	2.13
P828	10		.28	2.38

PANASONIC POLYESTER CAPACITORS

100 VDC plus minus 10% TOLERANCE

NEW! KIT
150 POLYESTER CAPACITORS
Price includes convenient divided plastic box with bin guide for easy storage and quick access.
ASSORTMENT OF 15 POPULAR VALUES PANASONIC QUALITY

CAT. NO. M-KIT
ONLY $34.95

PART NO.	CAP (UFD)	PRICES 1	PAK OF 10	PAK OF 100	PAK OF 1000
M1102	.001	.14	1.17	8.34	75.04
M1122	.0012	.14	1.17	8.34	75.04
M1152	.0015	.14	1.17	8.34	75.04
M1182	.0018	.14	1.17	8.34	75.04
M1222	.0022	.14	1.17	8.34	75.04
M1272	.0027	.14	1.17	8.34	75.04
M1332	.0033	.14	1.17	8.34	75.04
M1392	.0039	.14	1.17	8.34	75.04
M1472	.0047	.14	1.17	8.34	75.04
M1562	.0056	.14	1.17	8.34	75.04
M1682	.0068	.14	1.17	8.34	75.04
M1822	.0082	.14	1.17	8.34	75.04
M1103	.01	.14	1.17	8.34	75.04
M1123	.012	.14	1.22	8.65	77.85
M1153	.015	.14	1.22	8.65	77.85
M1183	.018	.15	1.24	8.80	79.20
M1223	.022	.15	1.26	8.94	80.44
M1273	.027	.15	1.26	8.94	80.44
M1333	.033	.15	1.28	9.10	81.80
M1393	.039	.16	1.32	9.40	84.60
M1473	.047	.16	1.35	9.60	86.18
M1563	.056	.17	1.46	10.38	93.38
M1683	.068	.18	1.51	10.74	96.64
M1823	.082	.18	1.55	11.07	99.57
M1104	.1	.19	1.58	12.28	101.48
M1124	.12	.21	1.80	12.85	115.65
M1154	.15	.23	2.01	14.30	128.70
M1184	.18	.26	2.26	16.09	144.79
M1224	.22	.28	2.38	16.98	152.78
M1274	.27	.32	2.72	19.40	174.60
M1334	.33	.34	2.96	21.12	190.02
M1394	.39	.35	3.35	23.88	214.88
M1474	.47	.41	3.58	25.57	230.02

PLESSEY "MINI-BOX"

Metalized Poly. Cap. Kit

140 CAPACITORS
Price includes convenient divided plastic box with bin guide for easy storage and quick access.
ASSORTMENT OF 14 POPULAR "MINI-BOX" CAPACITORS

CAT. NO. 3050P-Kit
ONLY $35.95

PANASONIC ELECTROLYTIC KIT

150 CAPACITORS
Price includes convenient divided plastic box with bin guide for easy storage and quick access.
ASSORTMENT OF 15 POPULAR CAPACITORS

Cat. No. P6200-Kit
ONLY $35.95

E. F. JOHNSON PLUG & JACK KIT

150 COMPONENTS
Price includes convenient divided plastic box with bin guide for easy storage and quick access.
ASSORTMENT OF 150 POPULAR JACKS & PLUGS

Cat. No. J100-Kit
ONLY $69.95

PANASONIC DISC CAPACITORS

NEW! KIT
310 DISC CAPACITORS
Prices includes convenient divided plastic box with bin guide for easy storage and quick access.
ASSORTMENT OF 18 POPULAR VALUES PANASONIC QUALITY
(Tolerance: A - plus/minus 5%, B - plus/minus 10%, C plus 80%/minus 20%)

CAT. NO. DH-KIT
ONLY $24.95

Part Number	Capacitance	Tolerance	Voltage	10	100	1000
DH100	10PF	B	500V	.52	3.60	35.50
DH150	15PF	B	500V	.52	3.60	30.00
DH220	22PF	B	500V	.52	3.60	30.00
DH330	33PF	B	500V	.52	3.60	30.00
DH470	47PF	B	500V	.61	4.30	35.75
DH680	68PF	B	500V	.61	4.30	35.75
DH101	100PF	B	500V	.74	5.46	45.50
DH151	150PF	B	500V	.74	5.46	45.50
DH221	220PF	B	500V	.74	5.46	45.50
DH331	330PF	B	500V	.74	5.46	45.50
DH471	470PF	B	500V	.74	5.46	45.50
DH681	680PF	B	500V	.74	5.46	45.50
DH102	.001UFD	C	50V	.60	4.20	35.00
DH152	.0015UFD	C	50V	.60	4.20	35.00
DH222	.0022UFD	C	50V	.60	4.20	35.00
DH332	.0033UFD	C	50V	.60	4.20	35.00
DH472	.0047UFD	C	50V	.60	4.20	35.00
DH682	.0068UFD	C	50V	.60	4.29	35.75
DE103	.01UFD	C	25V	.84	6.30	50.00
DE223	.022UFD	C	25V	.84	6.30	52.50
DE333	.033UFD	C	25V	1.14	7.98	66.50
DE473	.047UFD	C	25V	1.09	8.40	70.00
DE104	.1UFD	C	25V	1.80	15.10	125.75

PANASONIC RESIN DIPPED TANTALUM CAPACITORS

NEW! KIT
180 TANTALUM CAPACITORS
Prices includes convenient divided plastic box with bin guide for easy storage and quick access.
ASSORTMENT OF 15 POPULAR VALUES PANASONIC QUALITY

CAT. NO. F-KIT
ONLY $79.95

Part No.	Cap (uF)	Voltage (V. DC)	Prices 1	Pak of 10	Pak of 100	1000
F35ER1	0.1	35	.38	3.21	26.70	240.30
F35ER15	0.15	35	.38	3.21	26.70	240.30
F35ER22	0.22	35	.38	3.21	26.70	240.30
F35ER33	0.33	35	.38	3.21	26.70	240.30
F35ER47	0.47	35	.38	3.21	26.70	240.30
F35ER68	0.68	35	.38	3.21	26.70	240.30
F25E1	1.0	25	.43	3.64	30.33	272.93
F16E1R5	1.5	16	.38	3.21	26.70	240.30
F16E2R2	2.2	16	.42	3.56	29.63	266.63
F16E3R3	3.3	16	.47	4.02	33.43	300.83
F16E4R7	4.7	16	.55	4.65	38.70	348.30
F16E6R8	6.8	16	.65	5.54	46.14	415.24
F16E10	10	16	.81	6.91	57.53	517.73
F16E15	15	16	1.06	9.06	75.50	679.50
F16E22	22	16	1.41	12.05	100.36	903.26

DIGI-KEY Precut/Prestripped Wire

Precut/Prestripped 100 Wire Package

Bulk Wire Wrap Wire

Wire Assortment No. WK-1-A
900 Precut/Prestripped No. 30 Wire Wrap Wire. Assortment consists of following lengths and quantities.

250—3"	100—4½"
250—3½"	100—5"
100—4"	10—6"

Catalog No. WK-1-A **$17.95**

Wire Assortment No. WK-2-A
2800 Precut/prestripped No. 30 Wire Wrap Wire. Assortment consists of following lengths and quantities.

250—2½"	250—5"
500—3"	100—5½"
500—3½"	250—6"
500—4"	100—6½"
250—4½"	100—7"

Catalog No. WK-2-A **$42.95**

Wire Stripped 1" both ends

PRECUT/PRESTRIPPED WIRE 100 Wires/Package

Part No.		Cost
B3	30-AWG Blue Wire, 3" Overall Length	$2.25
Y3	30-AWG Yellow Wire, 3" Overall Length	2.25
W3	30-AWG White Wire, 3" Overall Length	2.25
R3	30-AWG Red Wire, 3" Overall Length	2.25
B4	30-AWG Blue Wire, 4" Overall Length	2.40
Y4	30-AWG Yellow Wire, 4" Overall Length	2.40
W4	30-AWG White Wire, 4" Overall Length	2.40
R4	30-AWG Red Wire, 4" Overall Length	2.40
B5	30-AWG Blue Wire, 5" Overall Length	2.65
Y5	30-AWG Yellow Wire, 5" Overall Length	2.65
W5	30-AWG White Wire, 5" Overall Length	2.65
R5	30-AWG Red Wire, 5" Overall Length	2.65
B6	30-AWG Blue Wire, 6" Overall Length	2.90
Y6	30-AWG Yellow Wire, 6" Overall Length	2.90
W6	30-AWG White Wire, 6" Overall Length	2.90
R6	30-AWG Red Wire, 6" Overall Length	2.90
B7	30-AWG Blue Wire, 7" Overall Length	3.50
Y7	30-AWG Yellow Wire, 7" Overall Length	3.50
W7	30-AWG White Wire, 7" Overall Length	3.50
R7	30-AWG Red Wire, 7" Overall Length	3.50
B8	30-AWG Blue Wire, 8" Overall Length	3.75
Y8	30-AWG Yellow Wire, 8" Overall Length	3.75
W8	30-AWG White Wire, 8" Overall Length	3.75
R8	30-AWG Red Wire, 8" Overall Length	3.75

30 AWG Kynar Insulated in Bulk Continuous Length

Part No.	Color	Length	Cost
100 RD	Red	100 feet	$ 3.10
100 BK	Black	100 feet	3.10
100 BU	Blue	100 feet	3.10
500 RD	Red	500 feet	13.50
500 BK	Black	500 feet	13.50
500 BU	Blue	500 feet	13.50
1000 RD	Red	1000 feet	23.75
1000 BK	Black	1000 feet	23.75
1000 BU	Blue	1000 feet	23.75

The Digi-Key volume discount and Service charges are simple to apply. Most items sold by Digi-Key may be combined for a volume discount. Items that are not discountable are identified by the suffix-ND following the part number. After writing your order, total all of the discountable items and apply the appropriate discount. To this subtotal, add the non-discountable items. Then add the Service charge. We pay all shipping and insurance to addresses in the U.S.A., Canada and Mexico when payment accompanies order.

WHEN ORDERING BY PHONE, CALL: 1-800-346-5144 (Mn., Ak., Hi., call 218-681-6674) By mail send your order to: DIGI-KEY, Highway 32 South, Thief River Falls, MN 56701

You may pay by check, money order, Master Charge, VISA or C.O.D. ***DIGI-KEY GUARANTEE:*** Any parts or products purchased from Digi-Key that prove to be defective will be replaced or refunded if returned within 90 days from receipt with a copy of your invoice.

SERVICE	CHARGES
$ 0.00-$ 9.99	Add $2.00
$ 10.00-$25.00	Add $0.75
$ 25.00-$49.99	Add $0.50
$ 50.00-$99.99	Add $0.25
$100.00 & Up	No Charge

VOLUME	DISCOUNT
$ 0.00-$ 99.99	NET
$ 100.00-$249.99	Less 10%
$ 250.00-$499.99	Less 15%
$ 500.00-$999.99	Less 20%
$1000.00 & Up	Less 25%

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Capacitors•Real-Time Clock/Calendar• E F Johnson •Terminal Strips•T.I. Connectors•Wire Wrapping Supplies•CMOS•Rectifiers•Powerace•Sams Books•Diamond Tools•Panavice AP Products•Batteries•ZNR's•Books•Zenier Diodes•Breadboarding•Wire•Buzzers•Vises •Templates•Diodes•Switches•Drafting Aids•Soldering Supplies•Edge Connectors•IC Socket •Enclosures•Resistors & Resistor Networks•Hardware•Power Supplies•Hobby Blox•Phono Plugs & Jacks•Integrated Circuits•Optoelectronics•Lamps•Multimeter•LED's•Data Books Microprocessor & Support•Luxo Lamps•Clock Bezels•PC Layout Supplies•Lithium Batteries•Tantalum Capacitors•Time-Temperature Clock•A/D & D/A•Nickle-Cadmium Batteries Electrolytic Capacitors•Potentiometers•Car Clock•Transistors•Home Clock Kits•Tools • Fuse Holder Boards•Ungar Products•Heat Sinks & Accessories•Solder Wick•AND MORE

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Multi-Digit LED Numeric Series

Light Intensity (TYP)
1.6mcd at 10 mA

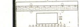
Forward Voltage (TYP)
1.7V at 10 mA

DEVICE TYPE	DIGIT SIZE	FORMAT	DRIVE	PRICE
NSN334	0.3" Red	+1.8.	CA, DIRECT	$3.00
NSN373		8.8. No D.P.	CC, DIRECT	$3.00
NSN374		8.8. No D.P.	CA, DIRECT	$3.00
NSN381		8.8.	CC, MULTI.	$3.00
NSN382		8.8.	CA, MULTI.	$3.00
NSN534	0.5" Red	+1.8.	CA, DIRECT	$3.50
NSN581		8.8.	CC, MULTI.	$3.50
NSN582		8.8.	CA, MULTI.	$3.50
NSN583		8.8.	CC, DIRECT	$3.50
NSN584		8.8.	CA, DIRECT	$3.50
NSN734	0.7" Red	+1.8.	CA, DIRECT	$4.00
NSN781		8.8.	CC, MULTI.	$4.00
NSN782		8.8.	CA, MULTI.	$4.00
NSN783		8.8.	CC, DIRECT	$4.00
NSN784		8.8.	CA, DIRECT	$4.00
NSB3382	0.3" Red	+1.8.8.8.	CA, MULTI.	$5.50
NSB3881		8.8.8.8.	CC, MULTI.	$5.50
NSB3882		8.8.8.8.	CA, MULTI.	$5.50
NSB5382	0.5" Red	+1.8.8.8.	CA, MULTI.	$6.50
NSB5881		8.8.8.8.	CC, MULTI.	$6.50
NSB5882		8.8.8.8.	CA, MULTI.	$6.50
NSB7382	0.7" Red	+1.8.8.8.	CA, MULTI.	$7.50
NSB7881		8.8.8.8.	CC, MULTI.	$7.50
NSB7882		8.8.8.8.	CA, MULTI.	$7.50

Red LED Lamps

NSL5053	Diffused red T1 ¾ lamp	$ 2.20/10 $19.50/100
NSL5056	Diffused narrow angle red T-1 ¾ lamp	$ 2.20/10 $19.50/100
NSC003	Optional Ring and clip for mounting NSL5053 and NSL5056	$ .30/10 $ 2.00/100

Bar/Dot Display Driver



NSM3914
Linear Display
NSM 3915
Logarithmic Display
NSM 3916
Logarithmic Display
$8.95 each
$77.50/10

Panasonic Batteries

CARBON ZINC BATTERIES

Part No.	Panasonic Model	Size	(V)	Each	Carton
P101	UM-1N	D	1.5	.94/1	17.14/24
P102	UM-2N	C	1.5	.60/1	12.05/24
P103	UM-3N	AA	1.5	.41/1	20.36/60
P104	006PN		9	1.81/1	12.91/12

ALKALINE BATTERIES

Part No.	Panasonic Model	Size	(V)	(mA)	Each	Carton
P105	AM-1	D	1.5	320	1.87/1	29.61/20
P106	AM-2	C	1.5	300	1.33/1	23.33/20
P107	AM-3	AA	1.5	130	.88/1	36.57/50

NICKEL CADMIUM BATTERIES

Part No.	Panasonic Model	(V)	Capacity 5 HR (mAh)	Each	Carton
P110	NR-N	1.2	150	2.39/1	199.50/100
P111	NR-N F1	1.2	150	2.70/1	266.00/100
P112	NR-AAA	1.2	180	2.47/1	249.00/126
P113	NR-AAA-F1	1.2	180	2.79/1	292.50/126
P108	NR-1/3AA	1.2	110	2.20/1	221.00/120
P109	NR-1/3AA-F1	1.2	110	2.53/1	254.00/120
P114	NR-2/3AA	1.2	250	2.39/1	399.00/200
P115	NR-2/3AA-F1	1.2	2.50	2.70/1	452.00/200
P116	NR-AA	1.2	500	2.42/1	161.00/80
P117	NR-AA-F1	1.2	500	2.70/1	183.55/80
P118	NR-1/2SC	1.2	600	3.57/1	443.70/150
P119	NR-1/2SC-F1	1.2	600	3.88/1	482.00/150
P120	NR-SC	1.2	1200	4.50/1	372.00/100
P121	NR-SC-F1	1.2	1200	4.81/1	398.00/100
P122	NR-C	1.2	1800	6.12/1	102.00/20
P123	NR-C-F1	1.2	1800	6.42/1	107.00/20
P124	NR-D	1.2	4000	11.04/1	92.00/10
P125	NR-D-F1	1.2	4000	11.34/1	94.50/10
P126	NR-F	1.2	7000	25.91/1	214.00/10
P127	NR-F-F1	1.2	7000	26.21/1	216.50/10

OK Machine made BC-3-115 Ni-Cad Battery Charger
INPUT: 110-120 VAC 60Hz
OUTPUT: 2.9 VDC at 200 mA
CAPACITY: 2 or 4 size AA, C, or D Ni-Cad
Part No. K251-ND **$15.95**

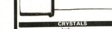
Ni-Cad batteries can typically be recharged 100 times and will replace from 100 to 300 regular batteries.

GELLED ELECTROLYTE LEAD ACID BATTERIES

Part No.	Panasonic Model	(V)	Capacity (Ah)	Each	Carton
P129	LCR-306P	6	3.0 (10h. rate)	15.86/1	290.00/24
P130	LCR-456P	6	4.5 (10h. rate)	22.70/1	422.22/24
P131	LCR-606P	6	6.0 (10h. rate)	27.10/1	506.50/24
P132	LCR-756P	6	7.5 (10h. rate)	39.70/1	373.00/12
P128	6M1.2	6	1.2 (20h. rate)	12.30/1	364.00/40

LITHIUM BATTERIES

Part No.	Panasonic Model	Type	(V)	Capacity (mAh)	Each	Carton
P140	BR425	Pin	3	20	2.16/1	180.00/100
P139	BR-435	Pin	3	40	2.16/1	180.00/100
P141	BR4005				.75/1	63.00/100
P135	BR-2325	Coin	3	150	2.67/1	445.00/200
P134	BR-1/2A	Cyl.	3	750	14.31/1	239.00/20
P133	BR-2/3A	Cyl.	3	1200	14.45/1	178.41/20
P136	BR-2320	Coin	3	110	2.67/1	445.00/200
P137	BR-2016	Coin	3	60	2.67/1	445.00/200
P138	CR-2016	Coin	3	50	2.67/1	445.00/200
P142	BR-2325MML1	Coin	3	160	5.15/1	429.00/100
P143	BR-2325MML2	Coin	6	160	9.53/1	797.50/100



CRYSTALS

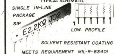
Cat. No.	Freq./MHz	Lead Length	Package	Price
X001	2.000	.250	HC-6/U	$ 3.20
X002	2.097	.200	HC-6/U	3.50
X003	2.560	.250	HC-6/U	2.15
X004	3.145	.500	HC-6/U	2.40
X005	3.579	.200	HC-6/U	3.95
X006	4.000	.200	HC-6/U	2.95
X007	4.194	.750	HC-6/U	2.89
X008	3.640	.250	HC-6/U	2.80
X009	3.840	.750	HC-6/U	2.80
X010	3.859	.250	HC-6/U	2.80

ELECTRONIC HARDWARE STEEL/ZINC PLATED

Part No.	Description	Price/C	Price/M
H130	2-56x1/4 Machine Screw, Slotted, Panhead	1.39	10.45
H134	2-56x1/2 Machine Screw, Slotted, Panhead	1.39	10.45
H138	2-56x3/4 Machine Screw, Slotted, Panhead	1.90	14.70
H142	4-40x1/4 Machine Screw, Slotted, Panhead	.99	7.45
H146	4-40x1/2 Machine Screw, Slotted, Panhead	.99	7.45
H150	4-40x3/4 Machine Screw, Slotted, Panhead	1.25	9.20
H154	6-32x1/4 Machine Screw, Slotted, Panhead	.99	7.45
H156	6-32x3/8 Machine Screw, Slotted, Panhead	1.25	9.20
H160	6-32x1/2 Machine Screw, Slotted, Panhead	.99	7.45
H164	6-32x5/8 Machine Screw, Slotted, Panhead	1.25	9.20
H168	6-32x3/4 Machine Screw, Slotted, Panhead	1.25	9.20
H172	6-32x1 Machine Screw, Slotted, Panhead	1.55	11.80
H176	8-32x1/4 Machine Screw, Slotted, Panhead	1.25	9.20
H180	8-32x3/8 Machine Screw, Slotted, Panhead	1.39	10.45
H184	8-32x1/2 Machine Screw, Slotted, Panhead	1.25	9.20
H188	8-32x5/8 Machine Screw, Slotted, Panhead	1.39	10.45
H192	8-32x3/4 Machine Screw, Slotted, Panhead	1.70	12.80
H196	8-32x1 Machine Screw, Slotted, Panhead	2.10	15.60
H200	10-32x1/2 Machine Screw, Slotted, Panhead	2.10	15.60
H204	10-32x3/4 Machine Screw, Slotted, Panhead	2.10	15.60
H208	10-32x1 Machine Screw, Slotted, Panhead	2.45	18.70
H212	2-56 Hex Nut	.75	5.60
H216	4-40 Hex Nut	.75	5.60
H220	6-32 Hex Nut	.75	5.60
H224	8-32 Hex Nut	.75	5.60
H228	10-32 Hex Nut	1.25	9.20
H232	No. 2 Internal Tooth Lock Washer	1.25	9.30
H236	No. 4 Internal Tooth Lock Washer	1.00	7.20
H240	No. 6 Internal Tooth Lock Washer	1.00	7.20
H244	No. 8 Internal Tooth Lock Washer	1.00	7.20
H248	No. 10 Internal Tooth Lock Washer	1.15	8.30

Panasonic

5% RESISTOR NETWORKS



TYPICAL SCHEMATIC
SINGLE IN-LINE PACKAGE SIP
E2.2KΩ J02
LOW PROFILE
SOLVENT RESISTANT COATING
MEETS REQUIREMENT MIL-R-83401

SWITCHING POWER SUPPLIES

This high quality switching power supply from PANASONIC are small, light and efficient. They measure 3.93x5.9x1.38 inch with an operating frequency of 50KHz. Complete specifications in the DIGI-KEY catalog.

DIGI-KEY Part Number	Panasonic Model Number	Output	Power	Price
ETU-5	ETU-5J40H	5V 4A	20W	$69.00
ETU-12	ETU-12J18H	12V 1.8A	20W	$69.00
ETU-15	ETU-15J15H	15V 1.5A	20W	$69.00
ETU-24	ETU-24J1CH	24V 1A	20W	$69.00

DIGI-KEY carries books by the following publishers
ADAM OSBORNE HAYDEN SYBEX TAB SAMS
Get your free DIGI-KEY catalog for the complete list of titles.

NATIONAL SEMICONDUCTOR DATA BOOKS

1978 CMOS Data Book — Published by National Semiconductor Corp. Cat. No. 9056B. **$6.00**

SC/MP Microprocessor Applications Handbook — This application guide is one tool in providing the user information on building, checking out and utilizing a wide variety of SC/MP-based systems. Published by National Semiconductor. Cat. No. 9022B. **$4.00**

1979 Special Function Databook — It contains detailed information for specifying and applying special amplifiers, buffers, clock drivers, analog switches, and D/A-A/D converter products. Published by National Semiconductor Corporation. Cat. No. 9057B. **$6.00**

1978 Linear Data Book — The Linear Data Book gives complete specifications for voltage regulators, op amps, voltage comparator-s/buffers, timers, consumer circuits (for AM/FM radios, TV, hi-fi/stereo, etc.), transistor/diode arrays, analog switches — circuits useful in almost any field of electronic design. Published by National Semiconductor Corp. Cat. No. 9058B. **$9.00**

Memory Data Book — Most of National's memory and memory-related products, regardless of their technology, are grouped together in the Memory Data Book. Published by National Semiconductor Corp. Cat. No. 9059B. **$6.00.**

1978 Discrete Databook — Contains technical data on the following national devices: NPN Transistors, PNP Transistors, PRO Electron Series, Jeida Series, NA/NB/NR Series. Published by National Semiconductor Corp. Cat. No. 9060B. **$5.00.**

1978 Data Acquisition Handbook — Contains information on and application notes for National Semiconductor parts in the product groups of: A/D & D/A converters, data acquisition systems, digital voltmeters, voltage references, analog switches/multiplexers, sample and hold and successive approximation registers. Cat. No. 9050B. **$7.00.**

1979 Memory Applications Handbook — Provides adequate information for user to put into practical use such memory hardware as: Dynamic & static read/write memory, ROM'S, PROM'S, EPROM'S, CRT display application and memory support as well as microprocessor guide. Cat. No. 9051B. **$11.00.**

1977 Pressure Transducer Handbook — Contains the pertinent facts on National Semiconductor pressure transducers. Cat. No. 9052B. **$3.00**

1979 Microcomputer Systems Series/80 Databook — Contains information on what to get and where to get it in order to build up a series 80 microcomputer of your own choosing. Cat. No. 9053B. **$5.00.**

Linear Applications Handbook — The purpose of this handbook is to provide a fully indexed and cross-referenced collection of linear integrated circuit applications using circuits from National Semi-conductor. Cat. No. 9062B. **$16.00**

Microprocessor Applications In Business, Science and Industry — Some real life uses of the Microprocessor in business, science and industry of which a person can take advantage. Cat. No. 9055B. **$4.00.**

Series 8000 Microprocessor Family Handbook — This valuable reference provides information of sufficient detail to design and develop microprocessor systems based on National's series 8000 family including the proven and popular 8080A CPU. The reference includes information on Nationals microbus memory components including maxi ROM'S peripheral and communications components and interfacing. Cat. No. 9061B. **$6.00**

Interface Data Book - 1980 — Peripheral/power drivers, level transistors/buffers, line drivers and receivers, memory and clock drivers, sense amplifiers, display drivers, opto-couplers . . . you'll find them all in the Interface Data Book. Published by National Semiconductor Corporation. 464 pages. Cat. No. 9064B. **$6.00**

Voltage Regulator Handbook - 1980 — The text takes you from the raw basics of power-supply design through heat flow and thermal resistance theory (including custom heat sink design and commercial sink selection), and on to applications. Published by National Semiconductor Corporation. 128 pages. Cat. No. 9063B. **$7.00**

CRIMP TOOL SET

CRIMP TOOL SET

CRIMP TOOL SET includes high quality crimp tool & as well as a specially selected assortment of terminals and connectors. (pictured at right). Set is designed for wire sizes 16 through 22 gauge.

NF-KIT **$19.95**

NEW UNGARmatic®

Temperature Controlled Soldering Station

THREAD-TOGETHER MODULAR DESIGN FOR QUICK, ON-LINE HEATER OR TIP CHANGE

50T6U-ND $76.58

- Closed loop, non-magnetic control.
- Low voltage system; 3 wire grounded.
- Biomechanical designed handle with cool grip for operator comfort. Cord is super flexible 3 wire grounded, heat resistant.
- Large capacity snap-on tray and sponge; removable for optional placement.
- Long life interchangeable tips, iron clad, chrome plated, pre-tinned.
- Designed for use on sensitive components.

HEAT GUN

Convenient hot-off-cold switch at trigger position.
Temperature approximately 750° to 800° F at nozzle in seconds.
Lightweight, only 13 ounces including 6 foot full length 3 wire cord.
Ideal For . . . • Solder Preform • Shrink Tubing • Reflow Soldering • Epoxy Curing • Cooling or Drying Components • Hot-melt Adhesive Reflow • Vinyl Repair

Part No.	Description	Price
6966CU-ND	Heat Gun	$59.95
6956U-ND	Shrink Tubing Reflector	.77
6957U-ND	Shrink Tubing Reflector	.77
6958U-ND	Reducing Baffle	1.67
6964U-ND	Precision Reflector	3.42
6965AU-ND	Heat Gun Holder	6.63

HOT-VAC® DESOLDERTOOL TOOL

Desolder 50% faster . . . reduce PC repair and rework time. HOT-VAC melts and removes solder with one-hand operation. Other hand is free to lift components. Solder reservoir is easily emptied.

7800U-ND Hot-Vac® Desoldering Tool $30.28

Replacement tips, solder, and other soldering equipment from UNGER

AP PRODUCTS INCORPORATED

A C E 218

Part No. 923326 .... $46.95

1,760 SOLDERLESS PLUG-IN TIE POINTS CAPACITY: UP TO 18 14-PIN DIP'S

- Two 5-way binding posts
- Size: 6-1/2" by 7-1/8"
- Fully assembled

A C E 227

Part No. 923325 .... $59.95

2,712 SOLDERLESS PLUG-IN TIE POINTS CAPACITY: UP TO 27 14-PIN DIP'S

- Four 5-way binding posts
- Size: 8" by 9-1/4"
- Fully assembled

A C E 236

Part No. 923324 .... $79.95

3,648 SOLDERLESS PLUG-IN TIE POINTS CAPACITY: UP TO 36 14-PIN DIP'S

- Four 5-way binding posts
- Size: 10-1/4" by 9-1/4"
- Fully assembled

Order No. 1000

A C E 200-K

Part No. 923333 .... $18.95

728 SOLDERLESS PLUG-IN TIE POINTS CAPACITY: UP TO 8 16-PIN DIP'S

- Two 5-way binding posts
- Size: 4-9/16" by 5-9/16"
- Kit form - lowest cost

A C E 208

Part No. 923332 .... $28.95

872 SOLDERLESS PLUG-IN TIE POINTS CAPACITY: UP TO 8 16-PIN DIP'S

- Two 5-way binding posts
- Size: 4-9/16" by 5-9/16"
- Fully assembled

A C E 201-K

Part No. 923334 .... $24.95

1,032 SOLDERLESS PLUG-IN TIE POINTS CAPACITY: UP TO 12 14-PIN DIP'S

- Two 5-way binding posts
- Size: 4-9/16" by 7"
- Kit form

A C E 212

Part No. 923331 .... $34.95

1,224 SOLDERLESS PLUG-IN TIE POINTS CAPACITY: UP TO 12 14-PIN DIP'S

- Two 5-way binding posts
- Size: 4-9/16" by 7"
- Fully assembled

BREADBOARD JUMPER WIRE KIT

Each kit contains 350 wires cut to 14 different lengths from 0.1" to 5.0". Each wire is stripped and the leads are bent 90 degrees for easy insertion. Wire length is classified by color coding. All wire is solid tinned 22 gauge with PVC insulation. The wires come packed in a convenient plastic box.

JK1 923351 .... $10.95

INTERFACE YOUR TRS-80-TO THE REAL WORLD

A 24" 40 conductor flat ribbon cable assembly with a socket connector on one end, a card-edge connector on the other. It's preassembled and every line is pretested.

924150-24 .... $11.95

JUMPER HEADERS

On .10"x.10" Matric

STRAIGHT

No. Posts	Part Number	Price 2 sets
20	923862-R	$1.59
26	923863-R	$1.89
34	923864-R	$2.39
40	923865-R	$2.79
50	923866-R	$3.39

RIGHT ANGLE

No. Posts	Part Number	Price 2 Sets
20	923872-R	$1.89
20	923872-R	$1.89
26	923873-R	$2.39
34	923874-R	$2.99
40	923875-R	$3.49
40	923876-R	$4.29

MALE and FEMALE HEADERS

Female	Rows	Part No.	Price
	1	929974	$1.49
	2	929975	$3.09

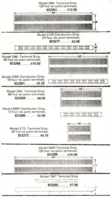
Male

A (.600)	Rows	Part No.	Ea.
Straight	1	929834-05	$2.29
Straight	2	929836-05	$4.59
Rt. angle	1	929835-03	$2.09
Rt. angle	2	929838-03	$4.59

Tall length shown as (.600) in dwgs.

Male

A (.100)	Rows	Part No.	Price Ea.
Straight	1	929834-01	$1.09
Straight	2	929836-01	$2.29
Rt. Angle	1	929835-01	$1.29
Rt. angle	2	929838-01	2.99



Model 264L Terminal Strip, 128 five-tie-point terminals, 923261 ...... $12.50

Model 212R Distribution Strip, 24 four-tie-point terminals, 923277 ...... $2.50

Model 248L Terminal Strip, 96 five-tie-point terminals, 923265 ...... $10.00

Model 209R Distribution Strip, 18 four-tie-point terminals, 923281 ...... $2.25

Model 234L Terminal Strip, 68 five-tie-point terminals, 923269 ...... $8.50

Model 206R Distribution Strip, 12 four-tie-point terminals, 923285 ...... $2.00

Model 217L Terminal Strip, 34 five-tie-point terminals, 923273 ...... $4.75

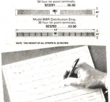
Model 264R Terminal Strip, 128 four-tie-point terminals, 923289 ...... $10.00

Model 154T Terminal Strip [illegible] 923292 ...... $7.00

Model 154R Terminal Strip, 54 four-tie-point terminals, 923291 ...... $6.00

Model 606R Distribution Strip, 36 four-tie-point terminals, 923293 ...... $3.50

NOTE: THE HEIGHT OF ALL STRIPS IS .32 INCHES.



LOGIC TIMING CHART

Now you can end the frustration of making logic timing charts by hand. You can change your timing all you need to on one piece of equipment. The new AP Products LOGIC TIMING CHART has 8 rows of 40 slides that can be changed as often as need be. When the timing is right the LOGIC TIMING CHART is copied in your office copier. You then have permenate record of your timing diagram.
Material: ABS Plastic; Dimensions: 11¾x8½x¼
Part No. 923758 .... $44.95

OK MACHINE & TOOL CORPORATION

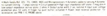
PRB-1 DIGITAL LOGIC PROBE

Compatible with DTL, TTL, CMOS, MOS and Microprocessors using 4 V to 15V power supply. Threshold automatically programmed. Automatic resetting memory.
• DC to 50 MHz • 10 Nsec. pulse response • 120 K impedance • Supply O.V.P. to plus minus VD • No switches, no calibration.

K137-ND	Digital Logic Probe	$36.95
K139-ND	Power cord (Alligator clips)	$4.95
K140-ND	Power Cord (Micro Hooks)	$9.95
K141-ND	High Voltage Adapter	$8.50
K142-ND	Replacement Probe Tip (2)	$1.50

PLS-1 LOGIC PULSER

The PLS-1 logic pulser will superimpose a dynamic pulse train (20 pps) or a single pulse onto the circuit node under test. There is no need to unsolder pins or cut printed circuit traces even when these nodes are being clamped by digital outputs.
• Multi-family RLE, DTL, TTL, CMOS, MOS and Microprocessors • Automatic polarity sensing • Automatic current limiting .7 amps nominal • Circuit powered • High input impedance (off state) 1 meg ohm • Low output impedance (active state) 2 ohms • Output pulse width 2 sec nominal • Input over voltage protection plus 50 volts • Finger tip push button actuated • Power lead reversal protection • For accessories see PRB-1 IC PROBE above.



K138-ND Logic Pulser $48.95

BATTERY WRAP TOOL

For .025 (0.63mm) sq. post. MODIFIED wrap, positive indexing, anti-overwrapping device.
USE "C" SIZE NI CAD BATTERIES
BATTERIES & BIT NOT INCLUDED

K106-ND	Battery Wrap Tool	$19.85
K102-ND	Bit For AWG 30	$3.95
K103-ND	Bit For AWG 26 & 28	$7.95

"HOBBY" WIRE WRAPPING TOOL BATTERY POWERED

For .025 (0.63mm) sq. post. MODIFIED wrap, positive indexing, anti-overwrapping device.

K100-ND	For AWG 30	$34.95
K101-ND	For AWG 26-28	$39.95
K102-ND	Bit For AWG 30	$3.95
K103-ND	Bit Or AWG 26-28	$7.95

USE "C" SIZE NI CAD BATTERIES NOT INCLUDED

RIBBON CABLE

26 AWG Rainbow Coded flat cable

K113-ND	14 Line, 5 Ft. Long	$2.85
K114-ND	16 Line, 5 Ft. Long	$3.15
K115-ND	24 Line, 5 Ft. Long	$4.35

OK Machine and Tool Corporation has done it again. Now you can get

ELECTRONIC HOBBY KITS

The only things you supply for these kits are batteries and tool. ALL other components are provided.

Part No.	Disc.	Battery	Price
K261-ND	Quick Reaction	4/AA	$ 9.90
K262-ND	Electronic Organ	1/9V	$11.89
K263-ND	Digital Roulette	4/AA	$14.90
K264-ND	Electronic Dice	4/AA	$13.80
K265-ND	Morse Code	1/9V	$ 6.51

SOCKET-WRAP I.D.

Identifies Pin Numbers on WW Sockets

Part No.	Disc.	Per Pack	Price
K266-ND	14 pin ID	10	$1.49
K267-ND	16 pin ID	10	$1.49
K268-ND	18 pin ID	5	$1.49
K269-ND	20 pin ID	5	$1.49
K270-ND	22 pin ID	5	$1.49
K271-ND	24 pin ID	5	$1.49
K272-ND	24 pin ID	5	$1.49
K273-ND	40 pin ID	5	$1.49
K274-ND	96 pin ID	5	$1.49

PC CARD GUIDES & BRACKETS

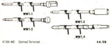
Includes 2 TR-1 guides plus 2 mounting brackets. Quantity: One set (4 pcs.)

K169-ND Guides & Brackets $3.79

OK MACHINE & TOOL CORPORATION

TERMINALS

• .025" (0.63mm) Square Post. Gold Plated. • 3 Level Wire-Wrapping. 25 per package.

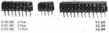


K184-ND	Slotted Terminal	$4.98
K185-ND	Single Sided Terminal	$2.98
K186-ND	IC Socket Terminal	$4.98
K187-ND	double Sided Terminal	$1.98

TERMINAL INSERTING TOOL
For inserting WWT-1, WWT-2, WWT-3, and WWT-4 Terminals into .040" (1.0mm) dia. Holes.

K188-ND Inserting Tool $2.49

P.C.B. TERMINAL STRIPS
The TS strips provide positive screw activated clamping action, accommodate wire sizes 14-30 AWG (1.6-0.25mm). Pins are solder plated copper .042 inch (1mm) diameter on .200 inch (5mm) centers.



K180-ND	4-Pole	$1.69
K181-ND	8-Pole	$2.59
K182-ND	12-Pole	$3.49

WIRE WRAPPING KIT WK-2

Contains: Hobby Wrap Tool, (50 ft.) roll of wire, Pre-stripped wire 1" to 4" lengths (50 wires per package) stripped 1" both ends

K171-ND	Wire-Wrapping Kit (Blue)	$12.95
K172-ND	Wire-Wrapping Kit (Yellow)	$12.95
K173-ND	Wire-Wrapping Kit (White)	$12.95
K174-ND	Wire-Wrapping Kit (Red)	$12.95

WIRE WRAPPING KIT WK-3

Contains: Hobby Wrap Tool, Roll of wire, (2) 14 DIP's, (2) 16 DIP's and Hobby Board H PCB-1

K175-ND Wire-Wrapping Kit (Blue) $16.95

WIRE WRAPPING KIT WK-4

Contains: Hobby Wrap Tool, Wire Dispenser, (2) 14 DIP's, (2) 16 DIP's, Hobby Board H PCB-1, DIP IC Insertion Tool INS-1416, DIP IC Extractor Tool EX-1 and PC Edge Connector CON-1

K176-ND Wire-Wrapping Kit (Blue) $25.99

WIRE WRAPPING KIT WK-5

Contains: • Battery Tool BW 630 • Hobby Wrap Tool WSU 30M • PC Edge Connector CON-1 • DIP IC Insertion Tool INS-1416 • PC Card Guides & Brackets TRS-2 • Mini Shear with Safety Clip MS-20 • 14, 16, 24 and 40 DIP PIN sockets • Terminals WWT-1 • Tri-Color Wire Dispenser WD-30-TRI • Hobby Board H PCB-1 • Product Catalog. Use "C" size NI-CAD batteries, not included

K177-ND Wire-Wrapping Kit $74.95

TRI-COLOR DISPENSER

3 Rolls of Wire in one dispenser • 3 colors: Blue, White, Red, 50 ft. of each color • AWG 30 (0.25mm) KYNAR insulated Wire • Built in Plunger cuts wire to desired length • Built in Stripper strips 1" of insulation • Refillable (for refills, see below)

K227-ND Tri-Color Dispenser $7.95

DISPENSER REPLACEMENT ROLLS

• AWG 30 (0.25mm) KYNAR insulated Wire • 3 Colors: blue, White, Red, 50 ft. each color • Silver plated, solid conductor, easy stripping

K228-ND Replacement Rolls $5.95

WIRE DISPENSER

• With 50 ft. Roll of AWG 30 KYNAR wire wrapping wire • Built in Plunger cuts wire to desired length • Built in Stripper strips 1" of insulation • Refillable (for refills, see below)

K223-ND	blue Wire	$4.95
K224-ND	Yellow Wire	$4.95
K225-ND	White Wire	$4.95
K226-ND	Red Wire	$4.95

DISPENSER REPLACEMENT ROLLS

Wire for wire wrapping, AWG 30 (0.25mm) KYNAR wire, 50 ft. roll, silver plated, solid conductor, easy stripping

K229-ND	30-AWG Blue 50 Ft. Roll	$2.98
K230-ND	30-AWG Yellow 50 Ft. Roll	$2.98
K231-ND	30-AWG White 50 Ft. Roll	$2.98
K232-ND	30-AWG Red 50 Ft. Roll	$2.98

HOBBY WRAP TOOLS

Wire wrapping, stripping, unwrapping tool for AWG 30 on .025 (0.63mm) Square Post

K104-ND	Regular Wrap	$6.95
K105-ND	Modified Wrap	$7.95

JUST WRAP,™ KITS, UNWRAP TOOL

WHY CUT? WHY STRIP? WHY SLIT? WHY NOT . . .
JUST WRAP™ WIRE WRAPPING TOOL

• AWG 30 Wire • .025 Square Posts • Daisy Chain or Point To Point • No Stripping or Slitting Required • JUST WRAP(TM) • Built in Cut Off • Easy Loading of Wire • Available Wire Colors: Blue, White, Red & Yellow

K144-ND	Just Wrap Tool - Blue	$14.95
K145-ND	Just Wrap Tool - White	$14.95
K146-ND	Just Wrap Tool - Yellow	$14.95
K147-ND	Just Wrap Tool - Red	$14.95

JUST WRAP REPLACEMENT ROLLS

K148-ND	Blue Wire 50 Ft. Roll	$2.98
K149-ND	White Wire 50 Ft. Roll	$2.98
K150-ND	Yellow Wire 50 Ft. Roll	$2.98
K151-ND	Red Wire 50 Ft. Roll	$2.98

UNWRAP TOOL FOR JUST WRAP

K250-ND Unwrapping Tool $3.49

JUST WRAP KIT

Contains: • JUST WRAP Tool • Roll of Blue Wire, 50 ft. • Roll of White Wire, 50 ft. • Roll of Yellow Wire, 50 ft. • Roll of Red Wire, 50 ft. • Unwrapping Tool

K152-ND Just Wrap Kit $24.95

ADJUSTABLE WIRE DISPENSER

• With 50 ft. of AWG 24 (0.5mm) or 100 ft. of AWG 30 (0.25mm) KYNAR wire wrapping wire • Built in Cutter cuts wire to desired length • Adjustable strip length 3/8 - 2" (9.5 - 51mm) • Interchangeable Strip Blade for alternate wire size • Refillable

K240-ND	24 AWG Blue Wire	$11.95
K241-ND	24 AWG Yellow Wire	$11.95
K242-ND	30 AWG Blue Wire	$11.95
K243-ND	30-AWG Yellow Wire	$11.95

DISPENSER REPLACEMENT ROLLS

Wire wrapping wire. Silver plated solid copper conductor. KYNAR insulated, easy stripping

K244-ND	50 Ft. 24 AWG Blue	$3.98
K245-ND	50 Ft. 24 AWG Yellow	$3.98
K246-ND	100 Ft. 30 AWG Blue	$3.98
K247-ND	100 Ft. 30 AWG Yellow	$3.98

REPLACEMENT STRIPPING BLADES

K248-ND	For 24 AWG (0.5mm)	$1.98
K249-ND	For 30 AWG (0.25mm)	$1.98

"CLIP AND STRIP" TOOL

Insert wire, squeeze tool closed to cut off excess wire, pull wire through stripping slot to removed insulation. The above cut and strip tool is not applicable for Mylene or Teflon insulation

K107-ND Clip And Strip $1.98

JUMPER WIRES

10 Preformed wires from ½ to 4 inches, 20 AWG solid wire, white insulation, ¼" bent at right angle

K239-ND Jumper Wires $2.98

Get your free catalog for the complete OK Listing.

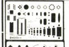
MODULAR TERMINAL STRIPS

K183-ND	2-Pole (3 per package)	$1.79
K168-ND	Card Guides	$1.89

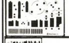
Guides accommodate any card thickness from .040-.100 inches. Quantity: One pair (2 pcs.)

Bishop Graphics

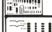
2X Scale PC design Two-Template Set 3373-ND **14.25**



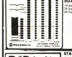
2X PC Design template I 3367-ND **8.90**



2X PC Design template II 3368-ND **8.90**



1X Scale PC Design Template 3365-ND **13.10**



DUAL IN-LINE TEMPLATE

1X Scale (2.25x2.75)	3375-ND	$ 4.35
2X Scale (4.76x5.25)	3376-ND	5.40
4X Scale (9x10.5)	3377-ND	7.00

STANDARD LOGIC SYMBOLS FOR DIGITAL DESIGN

CAT. NO.	SIZE	PRICE
3330-ND	Full: 7.75x4	$ 4.50
3331-ND	1/2: 5x3	4.50
3332-ND	3/4: 6.375x3.5	4.50
333-ND	3/8: 5x3	4.50
3334-ND	1/4: 3.5x2.5	4.50

Graphic symbols for electrical & electronic diagrams
3378-ND $ 7.50

SCETCH MATE
Cat. No. 3300-ND **$2.25**
METRIC SKETCH MATE
Cat. No. 3301-ND ... **$2.75**

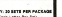
X-ACTO KNIFE

Order No. 3101-ND (X-Acto No. 1) **$1.38**

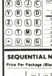
Order No. 3102-ND (X-Acto No 1SGK) **$2.70**

Order No. 3103-ND (X-Acto No. 3ST) **$2.70**
Pen knife with safety cap, clips to pocket.

(X-Acto No. 11)
Order No. 3108-ND 5-blade pack **$1.08**



(X-Acto No. 16)
Order No. 3110-ND (5-blade pack) **$1.08**



SEQUENTIAL ALPHABET KITS

QUANTITY: 20 SETS PER PACKAGE
(One Of Each Letter Per Set)

Height In.	Height mm	Cat. No.	Price Per Pkg. (Black)
.080	2.03	90308-ND	$12.65
.100	2.54	90310-ND	$12.65
.125	3.17	90312-ND	$12.65
.200	5.08	90320-ND	$16.20
.250	6.35	90325-ND	$16.20
.375	9.53	90337-ND	$19.40
.400	10.16	90340-ND	$19.40

SEQUENTIAL NUMBERS KITS

Price Per Package (Black)—$12.65

Set	Height (Inches & MM)						
	.080 (2.03)	.100 (2.54)	.125 (3.17)	.200 (5.08)	.250 (6.35)	.375 (9.53)	.400 (10.16)
01234	98008-ND	98010-ND	98012-ND	98020-ND	98025-ND	98037-ND	98040-ND
56789	98108-ND	98110-ND	98112-ND	98120-ND	98125-ND	98137-ND	98140-ND
Characters Per Pkg.	1250	1250	1250	1000	1000	750	500

DONUT PADS

Quantity: 500 Symbols/Pkg.

	OD IN.	OD MM.	ID IN.	ID MM.	CAT. NO.	Price PKG. (Black)
Standard Inch	.050	1,27	.015	0,38	D135-ND	$5.00
	.075	1,91	.025	0,64	D311-ND	$5.00
	.100	2,54	.031	0,79	D101-ND	$5.00
Not Etchant Immersible	.125	3,18	.040	1,02	D102-ND	$3.35
	.150	3,81	.031	0,79	D144-ND	$3.35
	.150	3,81	.040	1,02	D203-ND	$3.35
	.156	3,96	.031	0,79	D103-ND	$3.35
	.187	4,75	.040	1,02	D104-ND	$3.35
	.200	5,08	.040	1,02	D204-ND	$3.35
	.250	6,35	.062	1,57	D109-ND	$3.35
	.375	9,53	.062	1,57	D114-ND	$4.25
	.500	12,70	.062	1,57	D119-ND	$6.55

DUAL IN-LINE PACKAGE

(DIP) Pattern
Not Etchant Immersible

No. of Leads	Qty.	Scale	Cat. No.	Price Per Pkg. (Black)
8	250	1X	6487-ND	$11.45
	250	2X	6488-ND	$11.45
10	250	1X	6511-ND	$12.65
	250	2X	6512-ND	$12.65
14	250	1X	6014-ND	$12.65
	250	2X	6038-ND	$12.65
16	250	1X	6004-ND	$12.65
	250	2X	6109-ND	$12.65
18	250	1X	6900-ND	$12.65
	250	2X	6901-ND	$12.65
24	100	1X	6535-ND	$12.65
	100	2X	6536-ND	$12.65
28	100	1X	6903-ND	$12.65
	100	2X	6904-ND	$12.65
	100	1X	6559-ND	$12.65
36	100	2X	6560-ND	$16.20
	100	1X	6906-ND	$16.20
40	100	2X	6907-ND	$14.10

Precision Slit PC Artwork Tape

Not Etchant Immersible

Tape Size	MM. Equiv.	Order No. Black (T201) 20 Yds	Price Per Roll
.020	0.51	201-020-11-ND	$1.30
.031	0.79	201-031-11-ND	$1.30
.040	1.02	201-040-11-ND	$1.30
.050	1.27	201-050-11-ND	$1.30
.062	1.57	201-062-11-ND	$1.30
.080	2.03	201-080-11-ND	$1.30
.100	2.54	201-100-11-ND	$1.40
.125	3.18	201-125-11-ND	$1.40
.156	3.96	201-156-11-ND	$1.40
.200	5.08	201-200-11-ND	$1.40
.250	6.35	201-250-11-ND	$1.44
.300	7.62	201-300-11-ND	$1.44
.375	9.53	201-375-11-ND	$2.00
.400	10.16	201-400-11-ND	$2.00
.750	19.05	201-750-11-ND	$2.90

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LOOK AT THIS LS PRICING!

74LS00	.32
74LS01	.28
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74LS03	.32
74LS04	.35
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74LS10	.32
74LS11	.29
74LS12	.29
74LS13	.38
74LS14	.99
74LS15	.35
74LS20	.26
74LS21	.30
74LS22	.34
74LS26	.40
74LS27	.35
74LS28	.39
74LS30	.35
74LS32	.39
74LS33	.54
74LS37	.78
74LS38	.39
74LS40	.25
74LS42	.79
74LS47	.78
74LS48	.78
74LS51	.35
74LS54	.35
74LS55	.32
74LS73	.44
74LS74	.48
74LS75	.58
74LS76	.50
74LS78	.59
74LS83	.90
74LS85	1.23
74LS86	.45
74LS90	.70
74LS92	.82
74LS93	.71
74LS95	1.11
74LS96	.86
74LS107	.43
74LS109	.49
74LS112	.48
74LS113	.48
74LS114	.55
74LS122	.55
74LS123	.99
74LS125	.99
74LS126	.88
74LS132	.69
74LS136	.58
74LS138	.79
74LS139	.79
74LS145	1.19
74LS148	1.39
74LS151	.79
74LS153	.79
74LS154	2.39
74LS155	1.19
74LS156	.95
74LS157	.79
74LS158	.82
74LS160	.94
74LS161	.99
74LS162	.99
74LS163	.99
74LS164	.99
74LS165	.99
74LS166	2.40
74LS168	1.79
74LS169	1.79
74LS170	1.89
74LS173	.82
74LS174	1.19
74LS175	1.09
74LS181	2.19
74LS190	1.15
74LS191	1.31
74LS192	.88
74LS193	.98
74LS194	1.80
74LS195	1.39
74LS196	.82
74LS197	.82
74LS221	1.28
74LS240	1.89
74LS241	1.89
74LS242	1.89
74LS243	1.89
74LS244	1.79
74LS245	2.89
74LS251	1.32
74LS253	.89
74LS257	.89
74LS258	.89
74LS259	2.89
74LS260	.68
74LS266	.68
74LS273	1.69
74LS275	3.39
74LS279	.59
74LS283	1.03
74LS290	1.25
74LS293	1.89
74LS295	1.09
74LS298	1.24
74LS352	1.59
74LS353	1.59
74LS363	1.39
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7805K	1.39
7812K	1.39
7905T	.99
7912T	.99
7905K	1.49
7912K	1.49
78L12	.69

V = 8 PIN
K = TO-3
T = TO-220

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8257	16.95
8259	14.95
8275	49.95
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4 position	.99
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8 PIN	10/1.29
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Super Music Maker Kit $24.95

REVISION 2

Now you can play hundreds of songs using the Bullet **Super Music Maker.** The unit **features a single factory programmed microprocessor IC** that comes with 20 pre-programmed short tunes. By adding the additional PROMS (2708's) the system can be expanded to play up to **1000 notes per PROM.** Just think . . . a compact electronic instrument that will play dozens, hundreds or even thousands of selections of music. The kit comes with **all electronic components (less the PROM),** and a drilled, plated and screened PC Board which measures 4" x 4¾". The **7 watt amplifier** section is on the same PC board and drives an 8 ohm speaker (not included), from a whisper to ear splitting volume. Since the unit works on **12 VDC** or **12 VAC***, vehicle or portable operation is possible. **What do you get for $24.95? Everything but a speaker, transformer, case, switches,** and **PROM.** Additional 2708 albums containing popular tunes are available for **$15.00** each or you can program your own PROMS using information provided with the kit instructions. Lists of available PROM albums are available on request. *(Note: Unit plays electronic music one note at a time, it is not possible to play chords or a melody with harmony simultaneously.)*

OPTIONAL ACCESSORIES

DIP Switches One 8 pos., One 5 pos. (Can be **directly soldered** to PC Bd. to access tunes)	**2.00/Set**
Rotary Switches Two 5 position (For **remote wiring** to PC Bd. to access tunes)	***2.50*/Set**
Attractive Black Plastic Case	**6.50**
Wallplug Transformer (For operation on 117VAC house voltage)	**3.00**

Sound Effects Kit $18.50

The **SE-01 Sound Effects Kit** is a complete kit; all you need to build a programmable sound effects machine except a battery and speaker. Our kit is designed to really ring out the **TI 76477** Sound Chip. Only the SE-01 provides you with additional circuitry that includes a **PULSE GENERATOR, MUX OSCILLATOR and COMPARITOR** to make more complex sounds a snap. We help you in building the kit with a clear, easy-to-follow construction manual and we show you how to easily program the unit. Other dealers will sell you the chip or a "kit" of parts but you are on your own to do the most difficult part...make neat sounds! Within a short time after you build the SE-01 you can easily create **Gunshots, Explosions, Space Sounds, Steam Trains** and much more. We think the Bullet SE-01 is the best deal on the market but don't ask us. — ask the **15,000** happy SE-01 owners!

Complete Kit With Quality Plated PC Board **$18.50**
(Less battery & speaker)

7 Watt Audio Amp Kit $5.95

SMALL, SINGLE, HYBRID IC AND COMPONENTS FIT ON A 2" x 3" PC BOARD (INCLUDED). RUNS ON 12 VDC. GREAT FOR ANY PROJECT THAT NEEDS AN INEXPENSIVE AMP. LESS THAN 3% THD @ 5 WATTS. COMPATIBLE WITH SE-01 SOUND KIT.

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The AY3-8910 is a 40 pin LSI chip with three oscillators, three amplitude controls, programmable noise generator, three mixers, an envelope generator, and three D/A converters that are controlled by 8 BIT WORDS. No external pots or caps required. This chip hooked to an 8 bit microprocessor chip or Buss (8080, Z80, 6800 etc.) can be software controlled to produce almost any sound. It will play three note chords, make bangs, whistles, sirens, gunshots, explosions, bleets, whines, or grunts. In addition, it has provisions to control its own memory chips with two IO ports. The chip requires +5V @ 75ma and a standard TTL clock oscillator. A truly incredible circuit.

12.95 W/Basic Spec Sheet (4 pages)
60 page manual with S-100 interface instructions and several programming examples, **$3.00 extra**

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74150	0.54
74151	0.38
74152	0.38
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74154	0.53
74155	0.38
74156	0.38
74157	0.38
74158	0.38
74160	0.48
74161	0.48
74162	0.48
74163	0.48
74164	0.51
74165	0.51
74166	0.54
74167	1.06
74170	0.84
74173	0.58
74174	0.46
74175	0.45
74176	0.47
74177	0.47
74178	1.04
74179	1.04
74180	0.48
74181	1.02
74182	0.53
74184	1.06
74185	1.06
74188	2.10
74190	0.50
74191	0.50
74192	0.50
74193	0.50
74194	0.48
74195	0.44
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74LS09	0.16
74LS10	0.15
74LS11	0.17
74LS12	0.17
74LS13	0.30
74LS14	0.60
74LS15	0.15
74LS20	0.15
74LS21	0.15
74LS22	0.15
74LS26	0.18
74LS27	0.16
74LS30	0.13
74LS32	0.17
74LS37	0.18
74LS38	0.18
74LS40	0.15
74LS42	0.42
74LS47	0.60
74LS48	0.51
74LS49	0.54
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74LS73	0.21
74LS74	0.21
74LS75	0.30
74LS76	0.23
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74LS83	0.47
74LS85	0.54
74LS86	0.24
74LS90	0.33
74LS92	0.33
74LS93	0.33
74LS95	0.54
74LS107	0.22
74LS109	0.22
74LS112	0.24
74LS113	0.24
74LS114	0.24
74LS122	0.41
74LS123	0.47
74LS125	0.33
74LS126	0.33
74LS132	0.47
74LS133	0.26
74LS136	0.26
74LS138	0.45
74LS139	0.45
74LS151	0.41
74LS152	0.41
74LS153	0.41
74LS154	0.72
74LS155	0.41
74LS156	0.41
74LS157	0.41
74LS158	0.41
74LS160	0.51
74LS161	0.51
74LS162	0.51
74LS163	0.51
74LS164	0.51
74LS168	$0.57
74LS169	0.57
74LS170	0.84
74LS173	0.60
74LS174	0.47
74LS175	0.47
74LS181	1.36
74LS190	0.58
74LS191	0.56
74LS192	0.56
74LS193	0.56
74LS194	0.74
74LS195	0.74
74LS196	0.56
74LS197	0.56
74LS221	0.58
74LS240	1.23
74LS241	1.23
74LS244	1.23
74LS251	0.54
74LS253	0.54
74LS257	0.41
74LS258	0.41
74LS259	0.41
74LS260	0.21
74LS266	0.27
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74LS283	0.47
74LS290	0.58
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74S09	0.24
74S10	0.23
74S11	0.23
74S15	0.23
74S20	0.23
74S21	0.24
74S22	0.23
74S30	0.23
74S32	0.38
74S40	0.24
74S50	0.24
74S51	0.24
74S60	0.24
74S64	0.24
74S65	0.24
74S74	0.36
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74S114	0.36
74S132	0.52
74S133	0.23
74S134	0.24
74S135	0.42
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74S151	$0.66
74S153	0.66
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4026	0.99
4027	0.36
4028	0.50
4029	0.58
4030	0.23
4031	1.12
4034	1.30
4035	0.71
4040	0.63
4041	0.54
4042	0.54
4043	0.54
4044	0.54
4045	0.89
4046	0.63
4047	0.64
4048	0.28
4049	0.28
4050	0.28
4051	0.54
4052	0.54
4053	$0.54
4060	0.59
4066	0.27
4068	0.21
4069	0.17
4070	0.23
4071	0.17
4072	0.17
4073	0.17
4075	0.17
4076	0.53
4077	0.38
4078	0.24
4081	0.17
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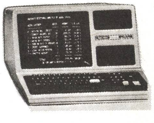

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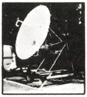

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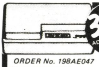

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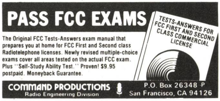

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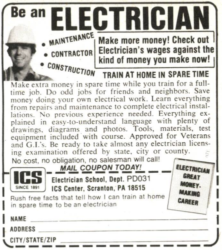

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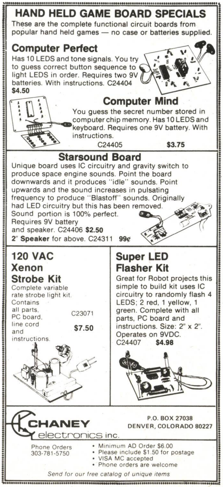

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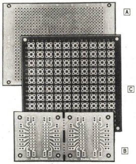

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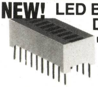

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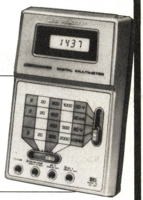

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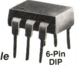

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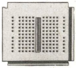

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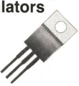

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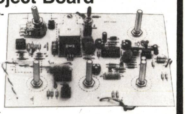

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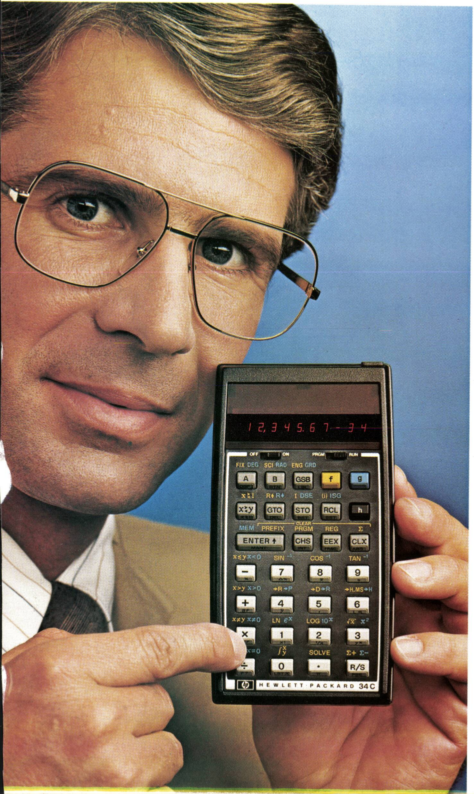

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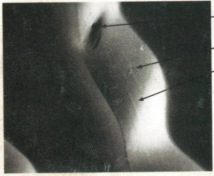
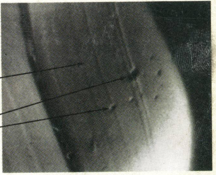


Pit from dust abrasion.

Ground-in microdust.

Prominent dust abrasion.

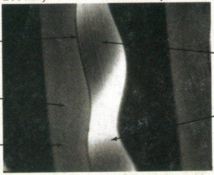
200 Plays Without Stylus Care



Prominent stylus path from abrasive-coated diamond face.

Vinyl particles welded by contaminated upper area of stylus.

200 Plays With Record and Stylus Care



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